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WATER RESOURCES
REPORT 11c

Northern Ontario Water Resources Studies

The Water Quality of Selected Lakes in the Arctic Watershed of Ontario

By
Arthur C. Roy

MINISTRY OF THE ENVIRONMENT
Northeastern Region
and
Water Resources Branch

Toronto Ontario

1979

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PREFACE

In October 1965, the Prime Minister of Canada and the Premier of Ontario agreed to undertake a series of co-ordinated studies of northern Ontario's water resources and related economic development. Subsequently, a co-ordinating committee representing the two levels of government was established and a statement of objectives for the studies was prepared as follows:

> "With respect to water draining into James Bay and Hudson Bay in Ontario, to assess the quantity and quality of water resources for all purposes; to determine present and future requirements for such waters, to assess alternative possibilities for the utilization of such waters locally or elsewhere through diversions".

This report deals with the interpretation of water quality data obtained by the Ontario Ministry of the Environment from selected lakes during the period from 1970 to 1973. Other reports by the Ministry of the Environment in the Northern Ontario Water Resources Study series deal with groundwater resources and streamflow characteristics and are published separately.

This report should be of interest to those who are concerned with the regional development of surface water resources and to those who are undertaking local studies in northern Ontario.

C. E. McIntyre, Director
Northeastern Region

G. H. Mills, Director
Water Resources Branch

Toronto, 1979

TABLE OF CONTENTS

PAGE

ABSTRACT x

INTRODUCTION 1

PURPOSE AND SCOPE 1
METHODS 4
ACKNOWLEDGEMENTS 6

WATER QUALITY: RESULTS AND INTERPRETATION 7

WATER CHEMISTRY 7

Calcium and Magnesium 7
Alkalinity 12
Sodium and Chloride 12
Silica 13
Iron 13
Sulphate 15
Tannins, Lignins and Colour 15
Nitrate 16
Total Kjeldahl Nitrogen 18
Total Phosphorus 18
Chlorophyll a 19
Turbidity and Secchi Disc 20
Dissolved Oxygen and Temperature 22

SEDIMENT CHEMISTRY 22

Total Kjeldahl Nitrogen, Water Content and Loss on Ignition 24
Total Phosphorus and Iron 27
Total Manganese 29

PHYTOPLANKTON POPULATIONS 29

Agusk Lake 32
Atikameg Lake 32
Attawapiskat Lake 32
Big Trout Lake 33
Big Trout Lake Bog 33
Blue Goose Lake 34
Bluejay Lake 34
Bog Lake 34
Brunswick Lake 35
Kaness Lake 35
Kasabonika Lake 35
Keezhik Lake 36
Lingen Lake 36
Lower Twin Lake 36
Lucy Lake 37
North Spirit Lake 37
Pierre Lake 38
Remi Lake 38
Saganash Lake 38
Sandybank Lake 39
Shagamu Bog 39

PAGE

Shagamu Lake....................................39
Shannon Lake....................................40
Streatfield Lake................................40
String Bog......................................41
Troutfly Lake...................................41
Wabimeig Lake...................................41
Wunnummin Lake..................................42

CHARACTERISTICS OF LAKE GROUPS.........................43

Group I — Bluejay, Troutfly and Lucy lakes.........43

Group II — Lower Twin, Remi, Brunswick, Saganash, Shannon and Keezhik lakes......45

Group III — Attawapiskat, Big Trout, Wunnummin, Pierre, North Spirit, Kaness and Kasabonika lakes.........................47

Group IV — Big Trout Lake Bog, String Bog and Shagamu Bog..............................47

Group V — Agusk, Bog, Sandybank, Shagamu, Atikameg, Streatfield, Lingen, Wabimeig and Blue Goose lakes............48

SUMMARY..50

REFERENCES...54

APPENDIX...57

A. MOE Bulletin References to Station Locations.......57

B. Graphs Depicting Temporal Variations in Phytoplankton Populations..........................67

FIGURES

Figure | Page

1. Location and extent of northern Ontario water resources studies area 1

2. Colour vs. concentrations of tannins and lignins in the study lakes 17

3. Chlorophyll a vs. total phosphorus concentrations in the study lakes 21

4. Secchi disc vs. chlorophyll a concentrations in the study lakes 23

5. Kjeldahl nitrogen concentrations vs. loss on ignition in the sediments of the study lakes.........26

6. Water content vs. Kjeldahl nitrogen concentrations in the sediments of the study lakes 28

7. Phytoplankton stocks and composition in the euphotic zone of Agusk Lake during the ice-free period of 1970 68

8. Phytoplankton stocks and composition in the euphotic zone of Atikameg Lake during the ice-free period of 1970 69

9. Phytoplankton stocks and composition in the euphotic zone of Attawapiskat Lake during the ice-free period of 1970 70

10. Phytoplankton stocks and composition in the euphotic zone of Big Trout Lake during the ice-free period of 1970 71

11. Phytoplankton stocks and composition in the euphotic zone of Big Trout Lake Bog during the ice-free period of 1970 72

12. Phytoplankton stocks and composition in the euphotic zone of Blue Goose Lake during the ice-free period of 1971 73

13. Phytoplankton stocks and composition in the euphotic zone of Bluejay Lake during the ice-free period of 1971 74

14. Phytoplankton stocks and composition in the euphotic zone of Bog Lake during the ice-free period of 1971 75

15. Phytoplankton stocks and composition in the euphotic zone of Brunswick Lake during the ice-free period of 1971 76

Figure Page

16. Phytoplankton stocks and composition in the euphotic zone of Kaness Lake during the ice-free period of 1970 77

17. Phytoplankton stocks and composition in the euphotic zone of Kasabonika Lake during the ice-free period of 1970 78

18. Phytoplankton stocks and composition in the euphotic zone of Keezhik Lake during the ice-free period of 1970 79

19. Phytoplankton stocks and composition in the euphotic zone of Lingen Lake during the ice-free period of 1971 80

20. Phytoplankton stocks and composition in the euphotic zone of Lower Twin Lake during the ice-free period of 1971 81

21. Phytoplankton stocks and composition in the euphotic zone of Lucy Lake during the ice-free period of 1970 82

22. Phytoplankton stocks and composition in the euphotic zone of North Spirit Lake during the ice-free period of 1970 83

23. Phytoplankton stocks and composition in the euphotic zone of Pierre Lake during the ice-free period of 1971 84

24. Phytoplankton stocks and composition in the euphotic zone of Remi Lake during the ice-free period of 1971 85

25. Phytoplankton stocks and composition in the euphotic zone of Saganash Lake during the ice-free period of 1971 86

26. Phytoplankton stocks and composition in the euphotic zone of Sandybank Lake during the ice-free period of 1970 87

27. Phytoplankton stocks and composition in the euphotic zone of Shagamu Bog during the ice-free period of 1970 88

28. Phytoplankton stocks and composition in the euphotic zone of Shagamu Lake during the ice-free period of 1970 89

29. Phytoplankton stocks and composition in the euphotic zone of Shannon Lake during the ice-free period of 1971 90

Figure Page

30. Phytoplankton stocks and composition in the euphotic zone of Streatfield Lake during the ice-free period of 1971 91

31. Phytoplankton stocks and composition in the euphotic zone of String Bog during the ice-free period of 1971 92

32. Phytoplankton stocks and composition in the euphotic zone of Troutfly Lake during the ice-free period of 1970 93

33. Phytoplankton stocks and composition in the euphotic zone of Wabimeig Lake during the ice-free period of 1971 94

34. Phytoplankton stocks and composition in the euphotic zone of Wunnummin Lake during the ice-free period of 1970 95

MAP

(in pocket)

MAP

1. Surface-water sampling locations, 1966 - 73

TABLES

Table Page

1. Chemical Analyses of Lake Water Samples 8-11

2. Sediment Data 25

3. Summary of Phytoplankton Data 30-31

4. Groupings of the Twenty-Eight Selected Lakes 44

ABSTRACT

As part of the Northern Ontario Water Resources Study carried out by the Ministry of the Environment from 1965 to 1972, water quality and phytoplankton data were collected from selected lakes in the five large river basins, (Moose, Albany, Attawapiskat, Winisk and Severn) that drain into Hudson Bay and James Bay (Arctic Watershed).

This report utilizes data from 28 lakes and bogs that were studied intensively to characterize the water quality of the various lakes within the study area. On the basis of morphology, water chemistry and phytoplankton populations, the 28 lakes are divided into five general groups. Three groups consisting of a total of sixteen lakes illustrate the general characteristics of lakes on the Precambrian Shield. One group consisting of three bogs and another group consisting of nine lakes illustrate the general characteristics of bogs and lakes on the Hudson Bay and James Bay Lowland.

INTRODUCTION

PURPOSE AND SCOPE

Under the Federal-Provincial Northern Ontario Water Resources Study (NOWRS), the Ontario Ministry of the Environment (MOE) conducted water quantity and water quality surveys of the five major river basins draining to Hudson Bay and James Bay. These included the Severn, Winisk, Attawapiskat, Albany and Moose river basins (Figure 1).

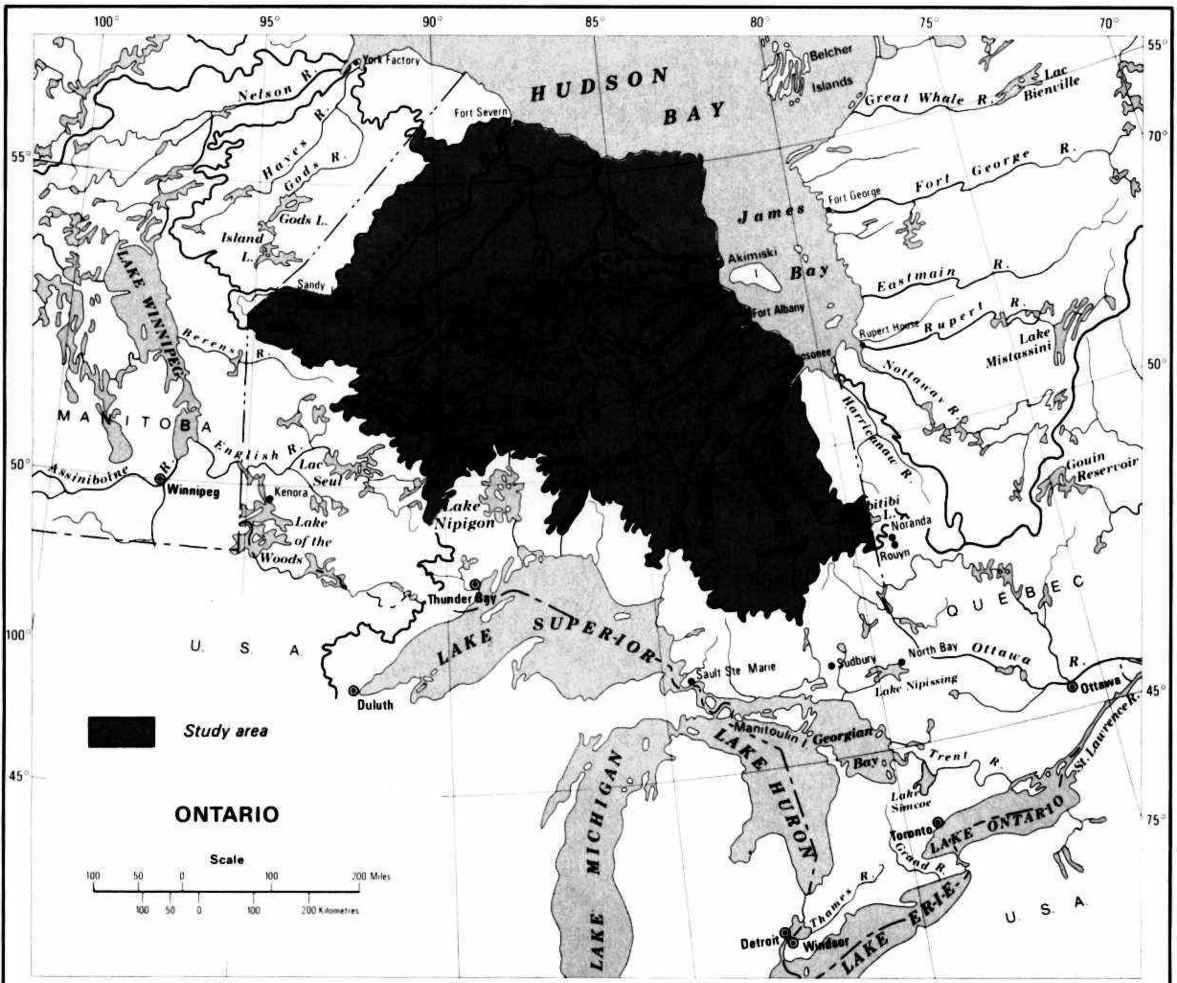

Figure 1. Location and extent of northern Ontario water - resources studies area.

As part of the Provincial responsibility, investigations of lake and river water quality, including physico-chemical and biological aspects, were carried out with emphasis on providing a background data base to permit evaluation of the impact of future development. This fundamental objective was realized with the publication of data Bulletins 1-1 to 1-5; however, certain aspects of the data base, particularly those related to lake water quality, merit some interpretation. The following report summarizes selected lake water quality data collected under the NOWRS and provides a general discussion of the physical, chemical and biological characteristics of lakes in the Arctic Watershed of Ontario.

Under the NOWRS, a total of 70 lakes were sampled between 1970 and 1973. Forty-two of these lakes were visited from 1 to 4 times during the open water period. An additional 28 lakes were sampled on a more intensive basis with samples collected 8 to 10 times during the open water period and once or twice under ice conditions. A complete listing of water quality and phytoplankton data collected under the NOWRS has been published by MOE (formerly Ontario water Resources Commission) in Bulletins 1-1 to 1-5. The locations of sampling stations and additional information on the sample collections are provided in Appendix A and on Map 1 (enclosed).

The present report is based primarily on data from the 28 intensively studied lakes; however, references to data for other lakes are included. The intensive lake studies were done to categorize bench-mark lakes i.e., representative of the various lake types encountered in the study area.

The following is a subdivision of the lakes according to their locations on either the Precambrian Shield or on the Hudson and James Bay Lowland :

	Lakes on Precambrian Shield	Lakes on Hudson and James Bay Lowland
Albany Basin:	Bluejay (43-06-33) Keezhik (43-06-75) Lower Twin (43-06-29) Lucy (43-06-27) Troutfly (43-06-76)	Blue Goose (43-06-34) Bog (43-06-61) Lingen (43-06-57) String Bog (43-06-62) Wabimeig (43-06-60)
Attawapiskat Basin:	Attawapiskat (44-06-05)	Streatfield (44-06-04)
Moose Basin:	Brunswick (42-06-35) Pierre (42-06-08) Remi (42-06-16) Saganash (42-06-18) Shannon (42-06-33)	
Severn Basin:	Big Trout (47-06-13) Kaness (47-06-51) North Spirit (41-06-42)	Agusk (47-06-26) Big Trout Lake Bog (47-06-12) Sandybank (47-06-11)
Winisk Basin:	Kasabonika (46-06-14) Wunnumin (46-06-27)	Atikameg (46-06-10) Shagamu Bog (46-06-05) Shagamu Lake (46-06-37)

Affixed numbers refer to sample locations shown on Map 1.

Although Big Trout Lake Bog and Sandybank Lake are located on the Precambrian Shield, their water chemistry, phytoplankton populations and general environment are somewhat more characteristic of Lowland bogs and lakes and they have therefore been grouped with lakes on the Hudson and James Bay Lowland.

The true locations of Bluejay and Blue Goose lakes in relation to the Precambrian Shield/Hudson and James Bay Lowland boundary are difficult to ascertain because of their close proximity to the mapped boundary. Their groupings are determined by their general water quality characteristics.

METHODS

Access to the majority of the lakes was by aircraft, consequently lightweight 500 ml plastic bottles were used to reduce weight, conserve space, and ease handling. The long distances involved and the inaccessibility of the remote sampling locations caused long delays in delivery of the samples to the laboratories in Toronto. Thus, perishable tests were either carried out in the field or on preserved samples.

Samples for chemical analyses were obtained as composites by quickly lowering a weighted sample bottle to a depth of twice the Secchi disc reading and raising it slowly so that it was nearly filled upon reaching surface. In addition, hypolimnetic samples were collected with a Kemmerer sampler when the lakes were deeper than twice the Secchi disc depth or when thermal stratification was evident. During each sampling visit three 500 ml samples were taken, two of which (one preserved with glacial acetic acid) were sent to Toronto for chemical analyses. The preserved sample was analysed for Fe, Ca, Mg, SO_4, SiO_2, NO_3, Kjeldahl N and total P. The unpreserved sample was analysed for Cl, tannins and lignins, Na, alkalinity and solids. The third sample was analysed at a field base for colour and turbidity. Colour was measured with a B.D.H. Lovibond Nessleriser and two Hazen colour discs (NSA and NSB)[1] ranging from 5 to 70 and 70 to 250 units on the Hazen Colour scale. Turbidity was determined using a Hach Kit-Model DR-EL.

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[1] Use of trade names is not an endorsement of the product.

Chlorophyll a and phytoplankton samples were also taken as euphotic zone composites. One ml of 2% $MgCO_3$ solution was added to chlorophyll a samples which were subsequently filtered through a membrane filter at base camp. Filters were forwarded to the Ministry of the Environment laboratories in Toronto for analyses. Phytoplankton samples were preserved with Lugol's iodine and sent to the Ministry of the Environment laboratories for identification and enumeration.

Temperature, dissolved oxygen, conductivity and Secchi disc readings were made at the beginning of each sampling. Dissolved oxygen tests were done using the Winkler method, with the final titration carried out at the field base. Temperature, conductivity and dissolved oxygen were measured at 1 m below surface and 1 m above bottom. Where thermal stratification occurred, vertical profiles of temperature and dissolved oxygen were taken.

Sediment samples were collected using an Ekman dredge. The top 2 cm of sediment were placed in an 85 ml jar, sent to the Ministry of the Environment laboratories, and analysed for total quantities of Fe, Mg, P, Kjeldahl N, water content, and loss on ignition.

ACKNOWLEDGEMENTS

The programme was conducted over an extended period of time and many persons, including Ministry and non-Ministry staff, were involved. All contributors are gratefully acknowledged and the author, at the risk of inadvertently omitting someone, thanks the following special contributors:

Dr. T. Brydges was responsible for interpretation of the water and sediment chemistry data.

Mrs. E. Carney performed the identification and enumeration of phytoplankton and assisted in the interpretation of the phytoplankton information.

Kipton Hawley assisted in the tabulation of data and in certain aspects of the interpretation.

Bill Keller and Nels Conroy contributed to the final preparation and editing of the manuscript.

The Word Processing Centre of the Northeastern Regional Office typed the drafts of the report.

Victor Chin reviewed and offered constructive criticism of the manuscript.

WATER QUALITY: RESULTS AND INTERPRETATION

WATER CHEMISTRY

Table 1 provides maximum, minimum and median values of selected chemical parameters. The data in Table 1 are grouped according to the 5 major river basins studied.

Calcium and Magnesium

Median surface-water concentrations of calcium ranged from 10 to 67 mg/l in the Precambrian Shield lakes and from less than 2 to 15 mg/l in the Lowland lakes, while the corresponding magnesium concentrations ranged from 2 to 18 mg/l and from less than 1 to 3 mg/l. Bluejay Lake, on the Precambrian Shield in the upper Albany basin exhibited an exceptionally high mineral content with calcium and magnesium medians of 67 and 18 mg/l, respectively. Bluejay Lake is approximately 20 m deep and is apparently fed primarily by groundwater intercepting an area of limestone and dolomite. Blue Goose Lake, 3 km away, in a similar geologic setting, is less than 3 m deep and had calcium and magnesium medians of only 14 and 3 mg/l, respectively. These latter values are likely more representative of local runoff.

Lakes in the upper Moose and Albany river basins generally contained about twice as much calcium and magnesium as lakes in the upper areas of the Attawapiskat, Winisk, and Severn river basins.

The calcium and magnesium content of the four lakes (Wunnummin, Kasabonika, Sandy and Attawapiskat) located on large rivers

TABLE 1. CHEMICAL ANALYSES OF LAKE WATER SAMPLES

LOCATION			Fe mg/l	SO_4 mg/l	SiO_2 mg/l	NO_3 mg/l	Kjeldahl/N mg/l	Total P mg/l	Cl mg/l	Tannins & Lignins mg/l	Alk as $CaCO_3$	Na mg/l	Ca mg/l	Mg mg/l
NAME	LAT.	LONG.												
ALBANY BASIN														
Blue Goose Lake (Comp)	50°00'	84°08'												
	Med		.10	< 5.0	1.0	< .01	.51	.021	1	0.8	43	0.7	14	3
	Max		.15	5.0	1.8	< .01	.53	.024	1	1.0	47	1.0	14	4
	Min		.10	< 5.0	0.3	< .01	.55	.017	< 1	0.5	41	0.7	12	2
Bluejay Lake (Comp)	50°02'	84°08'												
	Med		.05	7.5	10.3	< .01	.12	.006	1	0.0	238	2.1	67	18
	Max		.05	11.0	11.0	.02	.13	.008	1	0.0	257	2.5	72	20
	Min		< .05	7.0	9.6	< .01	.10	.004	< 1	0.0	214	2.0	58	18
Bluejay Lake (Bot)	50°02'	84°08'												
	Med		.05	9.0	10.0	< .01	.14	.012	1	0.0	270	2.6	79	19
	Max		.10	11.0	13.0	.02	.22	.014	1	0.0	274	3.0	79	24
	Min		< .05	< 5.0	8.5	< .01	.09	.006	< 1	0.0	229	2.0	63	19
Bog Lake (Comp)	51°31'	85°44'												
	Med		.25	7.0	1.4	< .01	.44	.028	1	1.5	7	<1.0	3	< 1
	Max		.35	14.0	1.7	.08	.71	.036	2	2.5	9	<1.0	4	1
	Min		.15	< 5.0	0.9	< .01	.42	.024	< 1	1.0	6	<1.0	3	< 1
Keezhik Lake (Comp)	54°45'	88°30'												
	Med		.12	< 5.0	2.7	< .01	.27	.018	1	0.4	70	1.0	22	3
	Max		.25	< 5.0	3.7	.03	.34	.041	1	0.5	77	1.0	26	4
	Min		.05	< 5.0	2.2	< .01	.24	.009	1	0.4	68	0.6	21	2
Keezhik Lake (Bot)	54°45'	88°30'												
	Min		.17	< 5.0	3.8	< .01	.30	.015	1	0.3	71	1.0	22	3
	Max		.50	< 5.0	6.1	.10	.64	.041	2	0.5	80	1.0	26	5
	Min		.10	0.0	2.3	< .01	.14	.004	1	0.0	70	0.6	22	1
Lingen Lake (Comp)	51°55'	85°15'												
	Med		.60	5.0	0.6	< .01	.47	.033	1	2.0	12	0.5	5	1
	Max		.80	5.0	0.8	< .01	.65	.035	1	2.0	14	< 1.0	6	1
	Min		.45	< 5.0	0.4	< .01	.23	.020	< 1	1.0	10	0.3	5	< 1
Lower Twin Lake (Comp)	50°10'	86°31'												
	Med		.05	< 5.0	3.7	< .01	.35	.010	1	0.5	79	< 1.0	25	5
	Max		.05	12.0	4.4	.03	.41	.011	1	0.5	89	1.0	28	5
	Min		.05	< 5.0	3.3	< .01	.31	.010	< 1	0.5	76	< 1.0	25	4
Lower Twin Lake (Bot)	50°10'	86°31'												
	Med		.15	< 5.0	4.7	< .01	.30	.014	< 1	0.25	80	0.9	25	4
	Max		.20	5.0	5.4	< .01	.35	.016	1	0.5	80	1.0	25	4
	Min		.10	< 5.0	3.9	< .01	.26	.012	< 1	0.0	79	0.8	25	4
Lucy Lake (Comp)	50°18'	87°13'												
	Med		.03	< 5.0	3.0	.01	.20	.010	1	0.0	116	1.0	34	7
	Max		.15	10.0	4.3	.04	.27	.012	1	0.0	122	1.0	38	7
	Min		< .05	< 5.0	2.9	< .01	.18	.008	1	0.0	112	1.0	33	6
Lucy Lake (Bot)	50°18'	87°13'												
	Med		.05	< 5.0	4.2	< .01	.22	.018	1	0.0	118	1.0	34	7
	Max		.15	12.0	5.2	.10	.43	.030	2	0.0	127	1.0	38	8
	Min		.02	< 5.0	3.4	< .01	.18	.005	1	0.0	114	<1.0	33	6

TABLE I. CHEMICAL ANALYSES OF LAKE WATER SAMPLES

LOCATION NAME	LAT.	LONG.	Fe mg/l	SO_4 mg/l	SiO_2 mg/l	NO_3 mg/l	Kjeldahl/N mg/l	Total P mg/l	Cl mg/l	Tannins & Lignins mg/l	Alk as $CaCO_3$	Na mg/l	Ca mg/l	Mg mg/l
String Bog (Comp)	51°31'	85°44'												
	Med		.20	5.0	1.7	< .01	.40	.018	1	3.7	3	1.0	< 2	< 1
	Max		.25	5.0	1.7	< .01	.60	.036	1	5.0	9	<1.0	3	< 1
	Min		.15	5.0	0.9	< .01	.38	.012	< 1	3.5	0	0.2	< 1	< 1
Troutfly Lake (Comp)	51°42'	88°55'												
	Med		.10	< 5.0	3.8	< .01	.19	.006	1	0.0	106	1.0	32	5
	Max		.10	< 5.0	4.4	.01	.23	.011	2	0.0	106	1.0	37	7
	Min		< .05	< 5.0	3.2	< .01	.17	.004	< 1	0.0	104	0.9	31	3
Troutfly Lake (Bot)	51°42'	88°55'												
	Med		.15	< 5.0	6.1	< .01	.27	.011	1	0.0	108	1.0	32	6
	Max		.30	< 5.0	6.7	.14	.71	.034	2	1.0	111	1.0	41	8
	Min		.05	0.0	4.1	< .01	.21	.007	1	0.0	104	1.0	31	5
Wabimeig Lake (Comp)	51°28'	85°35'												
	Med		.85	5.0	0.8	< .01	.58	.032	1	1.5	21	1.0	8	1
	Max		1.10	10.0	2.1	< .01	.73	.034	2	2.5	26	1.0	10	1
	Min		.30	5.0	0.6	< .01	.48	.011	1	1.0	16	0.5	7	1
ATTAWAPISKAT BASIN														
Attawapiskat Lake(Comp)	52°15'	87°55'												
	Med		.20	< 5.0	2.5	< .01	.37	.015	1	1.2	45	1.0	16	2
	Max		.35	5.0	3.5	.06	.47	.018	2	2.0	62	1.0	18	4
	Min		.15	1.0	2.1	< .01	.33	.013	< 1	1.0	40	0.5	13	2
Attawapiskat Lake(Bot)	58°15'	87°55'												
	Med		.25	< 5.0	3.1	< .01	.33	.016	< 1	1.2	46	1.0	14	3
	Max		.70	10.0	4.8	.06	.50	.034	2	2.0	64	1.0	22	1
	Min		.02	2.0	2.6	< .01	.30	.011	< 1	0.5	42	0.6	12	4
Streatfield Lake(Comp)	52°08'	85°55'												
	Med		1.10	5.0	0.9	< .01	.68	.044	1	1.2	18	0.8	7	< 1
	Max		1.70	5.0	1.1	< .01	.84	.058	1	1.5	23	1.0	9	1
	Min		.90	< 5.0	0.7	< .01	.50	.035	< 1	1.0	14	0.4	5	< 1
MOOSE BASIN														
Brunswick Lake (Comp)	49°00'	83°23'												
	Med		.10	7.0	2.3	< .01	.48	.021	1	0.3	81	0.7	26	5
	Max		.25	8.0	3.7	.02	.72	.026	2	1.0	83	1.0	27	5
	Min		.10	< 5.0	1.7	< .01	.33	.020	< 1	0.5	72	0.5	19	4
Brunswick Lake (Bot)	49°00'	83°23'												
	Med		.15	7.0	3.8	< .01	.39	.020	< 1	0.0	81	0.6	26	5
	Max		.20	7.0	5.5	.01	.72	.026	2	0.0	82	1.0	27	6
	Min		.10	< 5.0	3.0	< .01	.34	.016	< 1	0.0	80	0.6	24	5
Pierre Lake (Comp)	49°31'	80°44'												
	Med		.27	7.5	3.1	.01	.31	.015	1	0.8	45	0.9	15	3
	Max		.35	8.0	3.4	.02	.52	.022	2	1.0	46	1.0	18	4
	Min		.15	< 5.0	2.3	< .01	.27	.009	< 1	0.5	42	0.8	14	2
Pierre Lake (Bot)	49°31'	80°44'												
	Med		.40	5.0	3.5	< .01	.38	.022	< 1	0.5	46	1.0	15	3
	Max		.60	8.0	3.5	.02	.46	.028	2	1.0	47	1.0	16	3
	Min		.30	< 5.0	2.5	< .01	.30	.012	< 1	0.5	44	1.0	15	3

TABLE I. CHEMICAL ANALYSES OF LAKE WATER SAMPLES

LOCATION				Fe mg/l	SO_4 mg/l	SiO_2 mg/l	NO_3 mg/l	Kjeldahl/N mg/l	Total P mg/l	Cl mg/l	Tannins & Lignins mg/l	Alk as $CaCO_3$	Na mg/l	Ca mg/l	Mg mg/l
NAME	LAT.	LONG.													
Remi Lake (Comp)	49°25'	80°44'													
			Med	.10	< 5.0	3.0	<.01	.43	.020	2	0.0	84	1.0	27	5
			Max	.20	11.0	3.8	.06	.54	.022	3	0.5	95	1.2	30	7
			Min	.05	< 5.0	2.3	<.01	.34	.013	2	0.0	80	0.6	26	5
Remi Lake (Bot)	49°04'	82°10'													
			Med	.10	5.0	3.4	<.01	.43	.022	2	0.0	83	1.0	28	5
			Max	.20	5.0	3.8	<.01	.47	.026	2	0.5	84	1.2	28	5
			Min	.10	< 5.0	2.1	<.01	.30	.018	2	0.0	82	1.0	27	5
Saganash Lake (Comp)	49°04'	82°35'													
			Med	.25	8.0	3.0	<.01	.45	.020	1	0.5	84	1.0	26	5
			Max	.30	10.0	4.8	.04	.89	.024	2	0.5	95	1.1	30	6
			Min	.10	< 5.0	2.7	<.01	.36	.011	< 1	0.5	78	1.0	25	5
Shannon Lake (Comp)	49°47'	83°23'													
			Med	.10	< 5.0	1.0	<.01	.43	.018	1	0.0	76	0.7	24	4
			Max	.10	< 5.0	2.5	.01	.50	.022	1	0.0	78	0.6	25	5
			Min	.05	< 5.0	0.6	<.01	.31	.014	< 1	0.0	74	0.5	24	4
SEVERN BASIN															
Agusk Lake (Comp)	54°38'	89°30'													
			Med	.02	< 5.0	0.4	<.01	.46	.014	1	0.5	41	1.0	14	2
			Max	.35	5.0	0.7	.04	.55	.018	2	1.5	64	1.0	14	3
			Min	.10	2.0	0.1	<.01	.37	.011	< 1	0.2	38	0.8	13	1
Big Trout Lake (Comp)	53°45'	90°00'													
			Med	.05	< 5.0	0.8	<.01	.28	.014	1	0.5	56	1.0	18	2
			Max	1.50	< 5.0	1.1	.01	.36	.032	3	0.5	62	1.0	22	5
			Min	.02	< 5.0	0.6	<.01	.13	.004	< 1	0.4	54	< 1.0	16	1
Big Trout Lake (Bot)	53°45'	90°00'													
			Med	.15	< 5.0	1.2	<.01	.24	.016	< 1	0.2	55	1.0	18	2
			Max	.40	< 5.0	2.3	.04	.30	.020	1	0.5	58	1.0	20	3
			Min	.05	< 5.0	0.9	<.01	.13	.008	< 1	0.0	52	0.6	17	1
Big Trout Lake Bog(Comp)	53°51'	89°53'													
			Med	.17	< 5.0	2.7	<.01	.51	.009	1	1.6	58	1.0	22	2
			Max	.20	6.0	3.1	.02	.60	.016	2	1.7	60	1.0	23	2
			Min	.10	< 5.0	1.5	<.01	.24	.007	< 1	0.7	49	1.0	18	2
Kaness Lake (Comp)	52°31'	92°30'													
			Med	.30	< 5.0	3.1	<.01	.37	.016	1	1.4	33	1.0	11	2
			Max	.70	5.0	4.3	<.01	.38	.022	2	2.0	35	1.1	18	3
			Min	.15	< 5.0	1.9	<.01	.35	.009	< 1	1.0	31	1.0	8	2
Kaness Lake (Bot)	52°31'	92°30'													
			Med	.40	< 5.0	4.6	.06	.38	.038	< 1	1.5	33	1.0	11	2
			Max	.70	5.0	5.7	.13	.85	.060	1	2.0	34	1.1	11	3
			Min	.25	< 1.0	3.8	<.01	.32	.016	< 1	1.0	32	0.9	10	1
North Spirit Lake(Comp)	52°36'	93°00'													
			Med	.15	<5.0	3.2	<.01	.40	.013	1	1.5	27	1.0	10	2
			Max	.25	5.0	4.1	.04	.50	.016	1	2.0	29	1.0	14	4
			Min	.15	< 1.0	2.6	<.01	.33	.010	< 1	1.0	26	0.7	8	1
North Spirit Lake(Bot)	52°36'	93°00'													
			Med	.30	< 5.0	3.7	<.01	.37	.020	1	1.0	27	1.0	10	2
			Max	.60	10.0	5.3	.06	.47	.100	2	2.0	31	1.0	10	3
			Min	.15	< 1.0	3.0	<.01	.29	.012	< 1	1.0	26	0.7	8	1

TABLE I. CHEMICAL ANALYSES OF LAKE WATER SAMPLES

LOCATION NAME	LAT.	LONG.	Fe mg/l	SO_4 mg/l	SiO_2 mg/l	NO_3 mg/l	Kjeldahl/N mg/l	Total P mg/l	Cl mg/l	Tannins & Lignins mg/l	Alk as $CaCO_3$	Na mg/l	Ca mg/l	Mg mg/l
Sandy Lake (Comp)	52°36'	93°00'												
	Med		1.90	12.0	4.2	< .01	.53	.048	1	0.8	47	1.0	15	4
	Max		5.50	18.0	4.7	.04	.88	.066	2	1.5	50	1.6	18	6
	Min		1.5	< 5.0	2.5	< .01	.41	.011	< 1	0.15	38	1.0	12	2
Sandy Lake (Bot)	53°00'	93°00'												
	Med		3.40	14.0	4.1	.02	.55	.067	1	0.5	47	1.0	14	3
	Max		6.90	20.0	4.3	.06	.86	.200	1	1.5	50	1.5	17	6
	Min		1.4	5.0	3.6	< .01	.40	.048	< 1	0.5	38	1.0	12	2
Sandybank Lake (Comp)	53°00'	89°45'												
	Med		.30	< 5.0	1.0	< .01	.52	.018	1	0.5	43	1.0	14	2
	Max		.85	5.0	1.9	.01	1.5	.060	2	1.0	49	2.0	16	3
	Min		.15	2.0	0.6	< .01	.36	.016	< 1	0.5	37	0.6	13	1
WINISK BASIN														
Atikameg Lake (Comp)	54°15'	88°24'												
	Med		.30	< 5.0	0.4	< .01	.69	.037	2	1.6	16	1.0	6	1
	Max		1.00	7.0	0.6	< .01	.96	.056	2	3.0	17	1.1	14	3
	Min		.15	1.0	0.3	< .01	.46	.022	1	1.2	15	0.9	6	< 1
Kasabonika Lake (Comp)	53°35'	88°30'												
	Med		.15	< 5.0	2.2	< .01	.44	.011	1	0.8	55	1.0	16	3
	Max		.40	10.0	4.2	.14	.53	.023	2	1.2	84	1.0	25	4
	Min		.10	< 5.0	1.2	< .01	.36	.006	< 1	0.5	41	0.7	13	2
Shagamu Bog (Comp)	55°05'	87°04'												
	Med		.20	< 5.0	0.4	< .01	.49	.012	2	2.6	16	1.0	8	< 1
	Max		.40	5.0	0.7	< .01	.83	.070	3	5.0	19	1.4	9	2
	Min		.15	< 5.0	0.2	< .01	.43	.010	1	2.2	12	1.0	5	< 1
Shagamu Lake (Comp)	55°05'	87°05'												
	Med		.15	< 5.0	0.2	< .01	.41	.018	2	1.0	24	1.0	9	1
	Max		.25	5.0	0.4	.01	.56	.024	3	1.5	24	2.0	14	3
	Min		.10	< 5.0	0.1	< .01	.37	.014	1	0.6	22	1.0	7	< 1
Wunnummin Lake (Comp)	52°55'	89°15'												
	Med		.15	5.0	2.1	< .01	.37	.012	1	1.1	40	0.9	14	2
	Max		.25	10.0	3.6	.02	.60	.017	2	1.5	45	1.0	16	3
	Min		.10	< 5.0	1.6	< .01	.31	.010	< 1	0.5	36	0.6	12	2
Wunnummin Lake (Bot)	52°55'	89°15'												
	Med		.20	< 5.0	2.5	< .01	.37	.018	1	1.0	41	1.0	14	2.5
	Max		.50	3.0	3.4	.08	.43	.035	2	1.3	52	1.0	18	3
	Min		.10	< 1.0	1.5	< .01	.35	.013	< 1	0.5	36	0.6	12	2

was similar to that of the headwater lakes in their respective basins, which are located on the Precambrian Shield.

Alkalinity

Comparison of the calcium-magnesium, alkalinity (as $CaCO_3$) and conductivity data indicated that the waterborne mineral content was largely calcium and magnesium bicarbonates and, therefore, alkalinity closely paralleled calcium and magnesium concentrations. Alkalinities in the Lowland lakes were generally lower (0 to 43 mg/l) than in the Precambrian Shield lakes (27 to 238 mg/l). Bluejay Lake in the upper Albany basin had the highest median value of 238 mg/l.

The alkalinities of the Northern Ontario Precambrian Shield lakes were surprisingly high and indeed higher than alkalinities of lakes on the Precambrian Shield of south-central Ontario (Muskoka, Haliburton, Parry Sound, Nipissing areas). The minimum alkalinity of the sixteen Precambrian Shield lakes in northern Ontario was 27 mg/l (as $CaCO_3$) and nine of the sixteen had alkalinities greater than 60 mg/l. These values are significantly greater than reported alkalinities of less than 10 mg/l (as $CaCO_3$) for 70 lakes in south-central Ontario (Sparling and Nalewajko, 1970).

Alkalinities in the upper Moose and Albany basins were about twice those in the upper sections of the Attawapiskat, Winisk and Severn basins.

Sodium and Chloride

Concentrations of sodium rarely exceeded 1 mg/l and never exceeded 2.5 mg/l. Bluejay Lake, with a median value of 2.1

mg/l, was the only lake with a median greater than 1 mg/l. Chloride concentrations were generally 1 mg/l or less and never exceeded 2 mg/l in any of the lakes.

The consistently low sodium and chloride concentrations suggest that these elements might be valuable tracers of some types of wastes from future developments since both are present in significant concentrations in sewage and many industrial effluents.

Silica

Soluble silica concentrations were higher in the Precambrian Shield lakes than in the Lowland lakes, with surface median concentration ranges of 0.8 to 10 mg/l and 0.2 to 1.2 mg/l for the two groups, respectively. Concentrations in the bottom waters of the deep lakes were consistently higher than in surface waters. This is a normal occurrence and is believed to be due to release from the sediments (Hutchinson, 1957). Although the release mechanism is not clearly understood, it is apparently accelerated at low oxygen levels. Completely anoxic conditions were not observed in any of the lakes, but the largest differences in silica concentrations between surface and bottom corresponded to the lakes with the greatest oxygen depletion. Bluejay Lake was exceptional with no difference between surface and bottom concentrations of silica even though the dissolved oxygen was as low as 2 mg/l. Lucy Lake was opposite with a large silica concentration variation with depth and oxygen never below 5.9 mg/l.

Iron

Median concentrations in surface waters were generally in the range 0.05 to 0.40 mg/l with only four lakes well above this range.

Sandy Lake, in the upper Severn basin, had medians of 1.9 mg/l in the surface waters and 3.4 mg/l in the bottom waters, which appeared to be a direct consequence of the inflow of the Flanagan River which had a median concentration of 3.5 mg/l. The corresponding total phosphorus concentrations were also high in both the lake and the river. The water is turbid due to erosion of the bank material (varved clay) which was sampled and analysed. The Fe:P weight ratios for samples of bank material, river water, and surface and bottom waters of the lake were 52, 43, 45, and 52 to one respectively, indicating that river bank erosion is the probable source of the iron and phosphorus.

High iron concentrations were observed in Streatfield (1.1 mg/l), Lingen (0.60 mg/l) and Wabimeig (0.85 mg/l) lakes, which are situated within 80 km of each other in the lower Attawapiskat and Albany basins. The high iron concentrations seem to be representative of relatively localized conditions; however, Bog Lake and String Bog in the same general area had low iron concentrations of 0.25 and 0.20 mg/l, respectively. All five lakes are shallow (maximum depths of less than 2 m). Bog Lake and String Bog are quite small and are believed to have peat basins, which prevent interaction with the mineral soils below. The bottoms of Streatfield, Lingen and Wabimeig lakes consist of soil material.

There were no significant differences in median iron concentrations between the Precambrian Shield and Lowland lakes, and while the Lowland lakes tended to be in the upper part of the overall concentration range, there was considerable overlap.

Iron concentrations in lakes have been related to organic content, particularly the coloured compounds of the tannin and lignin type (Shapiro, 1964). This mechanism may be a factor giving rise to the higher iron concentrations in some of the coloured lowland lakes; however, there was no overall consistent numerical relationship between iron and the tannin and lignin concentrations.

Sulphate

Sulphate concentrations were generally less than 5 mg/l, the lower analytical detection limit of the method in use at the time. The highest median concentration was recorded in Sandy Lake (12 mg/l) in the surface waters.

Tannins, Lignins and Colour

The median concentrations of tannins and lignins, expressed as mg/l tannic acid, were generally higher in the Lowland lakes (0.5 to 3.7 mg/l) than in the Precambrian Shield lakes (0 to 1.5 mg/l). Lakes in the upper Albany and Moose River basins were particularly low in tannins and lignins with zero concentrations in many cases. These results are to be expected and reflect the muskeg and peat cover in most of the lowlands in comparison to the rock, sand, and till moraines in the upper basin areas.

The median colour values ranged from 0 to 150 Hazen units. Organic compounds of the tannin and lignin type are often responsible for colour in lake waters. Median colour values in Hazen colour units are plotted against median concentrations of tannins and lignins in Figure 2. A tendency toward higher colour values at higher concentrations of tannins and lignins is apparent from Figure 2; however, the correlation is poor ($r^2 = 0.53$).

Nitrate

Concentrations of nitrate nitrogen in surface waters rarely exceeded 0.01 mg/l during the summer months. Several lakes were sampled through the ice during the winter and the nitrate concentrations were consistently higher than observed during the summer for each lake. However, the maximum value observed was only 0.14 mg/l (Kasabonika Lake in March 1971).

Bottom water concentrations in the deep lakes were approximately equal to or greater than the surface values in all cases. The maximum values observed were 0.13 mg/l in Kaness Lake in August 1971, and 0.14 mg/l in Troutfly Lake in March 1971.

Nitrate concentrations followed expected patterns: low summer values due to uptake by algae, accumulation under the ice when algal growth was minimal, and accumulation in the bottom water as a result of regeneration from the sediments. None of the lakes became fully anoxic in the hypolimnion, therefore, nitrogen accumulated as nitrate rather than as ammonia.

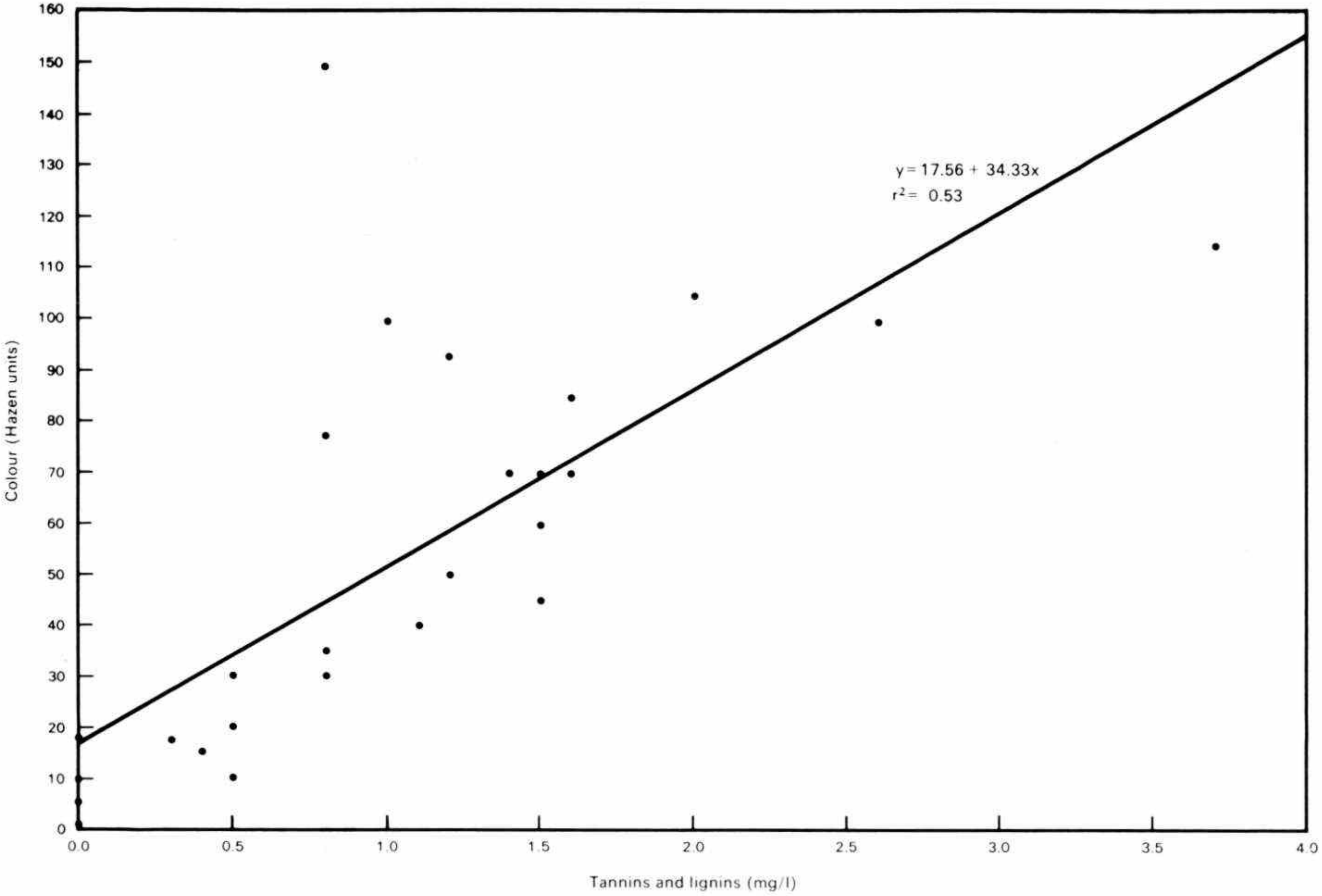

Figure 2. Colour vs. concentrations of tannins and lignins in the study lakes.

Total Kjeldahl Nitrogen

Median concentrations of total Kjeldahl nitrogen in surface waters ranged from 0.12 to 0.69 mg/l, and while there was considerable overlap between the Precambrian Shield lakes and the Lowland lakes, most of the Lowland lakes were in the top half of the overall range.

Bottom water median concentrations were similar to the surface values for all lakes. Kjeldahl nitrogen values are often higher in bottom waters due to accumulation of ammonia nitrogen from organic decomposition, particularly under anoxic conditions. When oxygen is present, as was the case in all lakes during the survey period, ammonia is converted to nitrate and Kjeldahl nitrogen values are not affected. As discussed above, nitrate nitrogen was higher in the bottom waters in all of the lakes.

Total Phosphorus

The median surface concentrations of total phosphorus for all lakes ranged from 0.006 to 0.048 mg/l. The values for the Precambrian Shield lakes were 0.022 mg/l or less, except Sandy Lake which was 0.048 mg/l, apparently due to suspended matter.

There were six lakes with values between 0.022 and 0.040 mg/l, all of which are less than 2 m deep and lie in the muskeg (lowland) areas of the Winisk, Albany and Moose basins. However, not all of the shallow lakes had high total phosphorus concentrations. For example, Big Trout

Lake Bog had one of the lowest phosphorus values (0.009 mg/l). The six lakes that had median phosphorus concentrations greater than 0.030 mg/l had correspondingly high iron concentrations. The weight ratios of iron to phosphorus were 18 or greater.

Atikameg Lake had a median iron value of only 0.30 mg/l and a total phosphorus median of 0.037 mg/l. While the median value of iron was not particularly high, individual concentrations up to 1.0 mg/l were observed in this lake. Marquis Lake was the only lake studied which had high phosphorus (0.034 mg/l) and consistently low iron (0.30 mg/l).

The two highest phosphorus concentrations were in Sandy Lake (0.048 mg/l) and Streatfield Lake (0.044 mg/l), and they corresponded to the two highest total iron medians of 1.9 and 1.1 mg/l, respectively. Sandy Lake is influenced by the Flanagan River which had high medians of phosphorus (0.058 mg/l) and iron (2.3 mg/l).

Chlorophyll a

Individual concentrations of chlorophyll a (Bulletin 1 - 5) were generally low and exceeded 5 ug/l at only five stations; Atikameg Lake (8.8 ug/l), NOWRS Bog (7.0 ug/l), Sandy Lake (7.5 ug/l), Kesagami Lake (7.0 ug/l) and Marquis Lake (7.2 ug/l). The median values ranged from 0.4 to 5.4 ug/l with the Lowland lakes tending to be in the upper part of the range.

No seasonal variations were identified, with maximum and minimum observed values falling at random times over the summer months.

Median chlorophyll a values are plotted against median total phosphorus concentrations in Figure 3. For comparison, a line representing data for the Kawartha lakes in southern Ontario (Nicholls, 1977) is included. While the overall chlorophyll a range in the present study is too small to support firm conclusions, the total phosphorus values generally do not support as much algae as might be expected of lakes further south in Ontario. This is likely a consequence of the high corresponding iron concentrations which may chemically bind the phosphorus and make it unavailable to algae. Sparling and Nalewajko (1970) found that for 70 southern Ontario lakes the algal standing crop was about three times greater in the hard-water lakes (conductivity greater than 150 umhos) than in the soft-water lakes (conductivity less than 150 umhos). This division between hard and soft-water lakes does not seem to hold for the northern lakes and in fact the hardest lake water had the lowest median chlorophyll a value, and the higher chlorophyll a concentrations were generally observed in the soft-water Lowland lakes.

Turbidity and Secchi Disc

Turbidity values (Bulletins 1-1 to 1-5) ranged from 0 to 80 Jackson Turbidity Units, with suspended matter in Sandy Lake giving rise to the highest value. The shallow lakes exhibited the majority of the higher values, as expected.

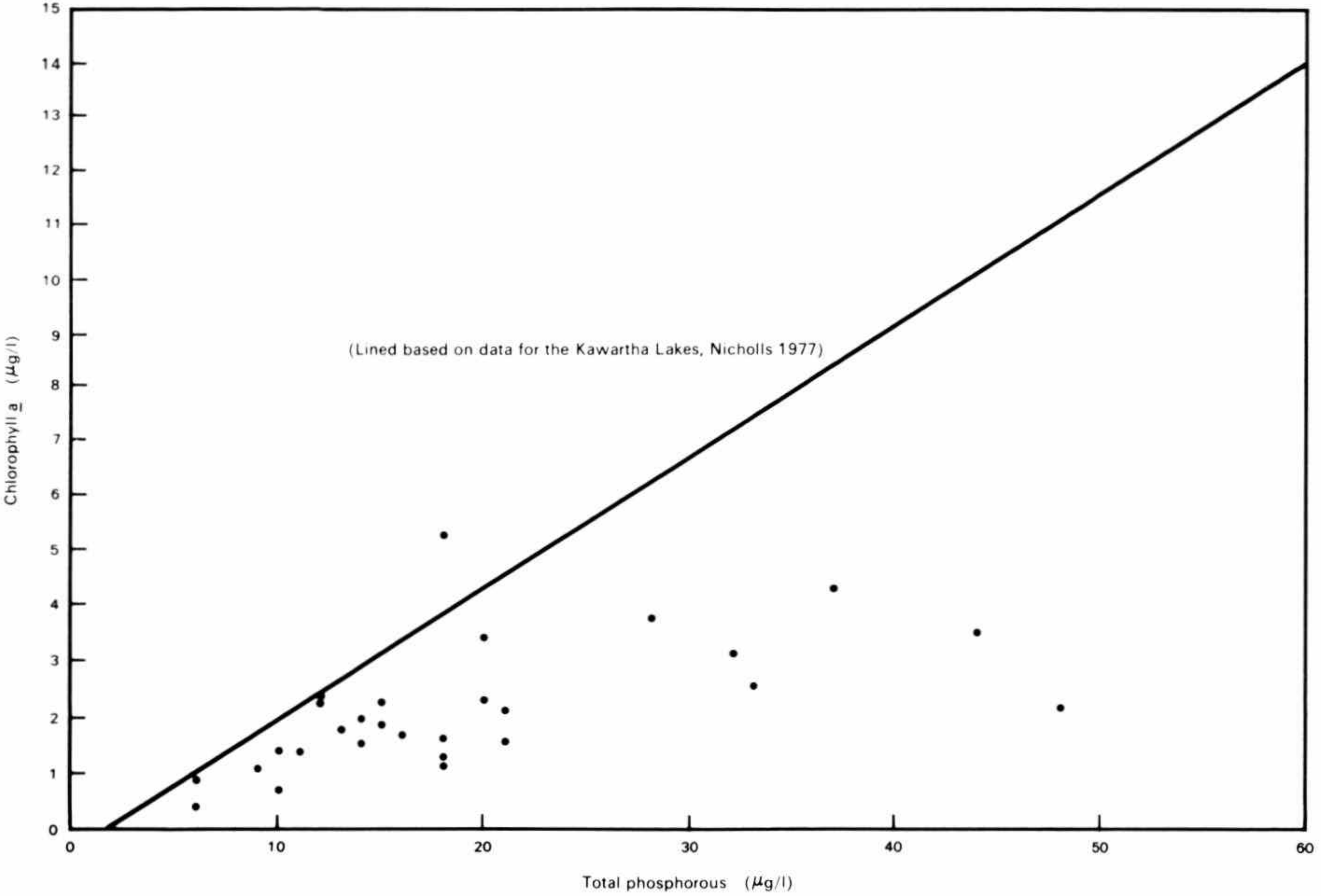

Figure 3. **Chlorophyll a vs. total phosphorous concentrations in the study lakes.**

phosphorus, iron, manganese, percent water content and loss on ignition. The samples were taken from the top 2 cm of material brought up in a dredge. The analytical data is presented in Table 2.

Total Kjeldahl Nitrogen, Water Content and Loss on Ignition

The total Kjeldahl nitrogen concentrations ranged from 0.35 to 24 mg/gm in dry sediment. These results are similar to those reported by Brunskill et al (1971) for 16 lakes near Kenora, Ontario, which ranged from 9.0 to 35.0 mg/gm dry weight.

The wide range of values accentuate previous observations (Konrad et al, 1970; Brydges, 1970) that the nitrogen content of the sediments does not relate directly to a lake's primary productivity. Some of the most oligotrophic lakes such as Keezhik and Troutfly had relatively high nitrogen concentrations in their sediments and Sandy Lake, with the highest chlorophyll a value, had a low sediment nitrogen value. The bog lakes generally had high concentrations of nitrogen in their sediments.

The Kjeldahl nitrogen concentrations are related to the percentage loss on ignition (Figure 5) which indicates that nitrogen is retained in the sediments by organic matter. Similar results have been previously reported for a wide variety of lake sediments, (Finger and Wastler, 1969; Brydges 1970). The wide range of loss on ignition values from 0.9

TABLE 2. SEDIMENT DATA

Concentrations of total phosphorus (P), Kjeldahl nitrogen (N), iron (Fe) and manganese (Mn) in mg/gm of dry sediment. The water content is the percentage loss of the wet weight on drying at 103^{o}C and the loss on ignition is the percentage loss of the dry weight on heating to 600^{o}C.

LAKE	P	N	Fe	Mn	% Water	% LOI
Big Trout Bog	1.3	24	2.8	0.24	92	65
Big Trout	1.7	8.6	48	3.6	84	16
Kaness	1.1	1.9	18	1.4	62	5.8
North Spirit	5.8	1.6	320	9.7	37	12
Sandy	1.2	1.7	43	5.1	76	6.3
Sandybank	0.68	24	11	0.3	96	54
Agusk	0.98	18	9.8	0.67	94	52
Kasabonika	1.3	10	41	0.98	89	23
Wunnummin	2.8	2.2	120	3.8	41	6.6
Atikameg	0.75	24	7.7	0.28	94	86
Shagamu	0.47	12	10	0.22	86	51
Shagamu Bog	0.50	22	9.3	0.26	90	87
Attawapiskat	1.1	2.1	30	3.2	65	8.2
Streatfield	0.51	4.7	12	0.30	66	17
BlueGoose	1.0	22	4.3	0.28	94	59
Bluejay	0.35	3.6	3.3	0.37	69	9.0
Keezhik	2.2	20	11	0.35	94	38
Lower Twin	1.2	4.0	9.4	2.5	73	11
Lucy*	0.37	0.96	11	0.40		4.3
Troutfly	1.7	17	9.1	0.29	93	32
Bog	0.55	16	2.9	0.46	91	67
Lingen	0.81	13	9.9	0.33	90	46
String Bog	0.48	13	0.6	0.19	93	93
Wabimeig**	0.26	0.35	5.6	0.24		0.9
Remi	0.95	6.7	14	1.1	83	16

* 25% large rocks

** 73% large rocks

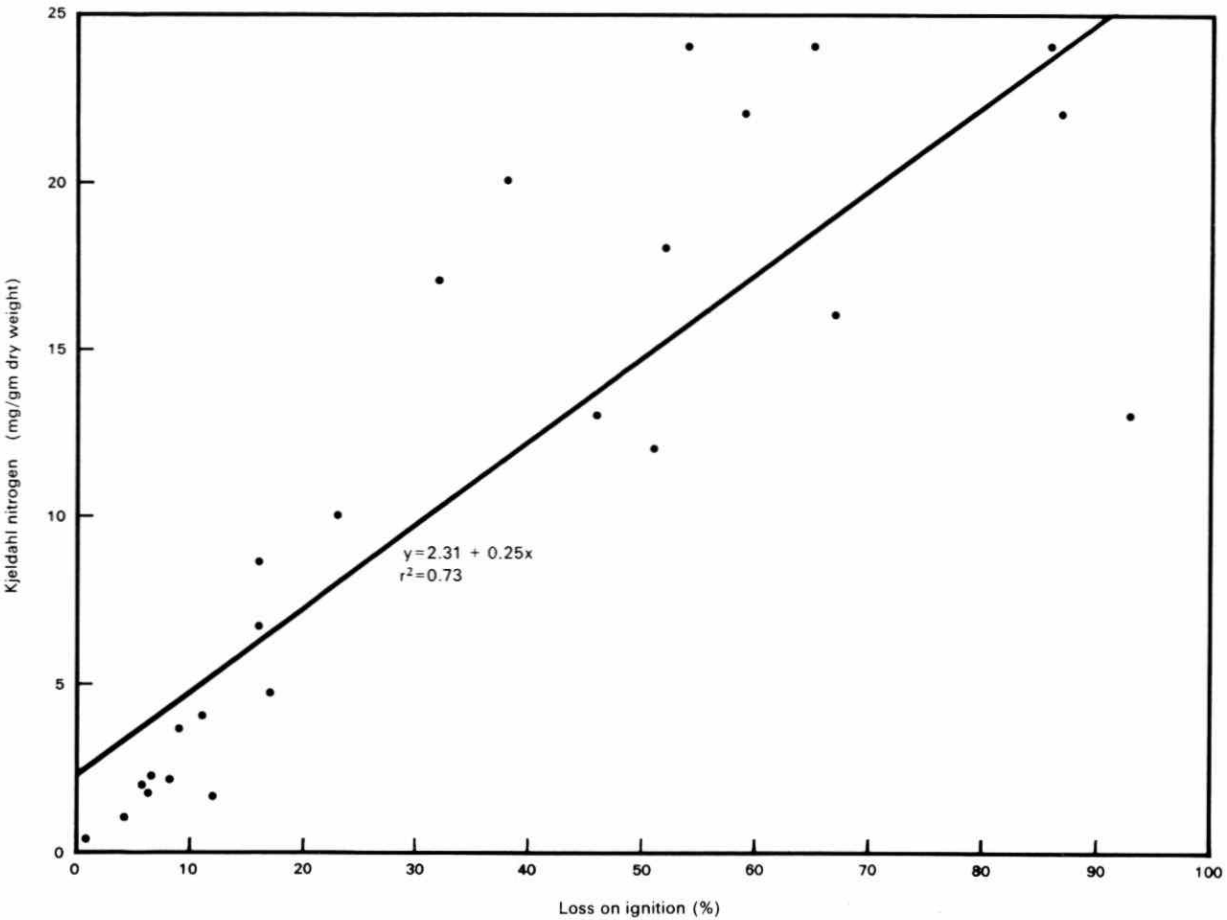

Figure 5. Kjeldahl nitrogen concentrations vs. loss on ignition in the sediments of the study lakes.

to 87 percent is surprising since the maximum values reported in the two references cited were 14 and 57 percent, respectively.

The water content of the sediments is related to the Kjeldahl nitrogen content (Figure 6). Each mg of nitrogen appears responsible for retaining 0.63 gm of water. The great affinity for water may be due to nitrogen in the form of proteins (Brydges, 1970) and if the sediment material is dried, it loses this affinity.

The water content of sediments from Lucy and Wabimeig lakes could not be determined because the coarse sand did not retain interstitial water during collection and handling.

Total Phosphorus and Iron

Total phosphorus concentrations in the lake sediments varied over a wide range from 0.26 to 5.8 mg/gm dry weight. The iron contents ranged even more from 0.6 to 320 mg/gm dry weight. High phosphorus and iron concentrations were generally associated, although there was no consistent numerical relationship between the two. These results support the observation that phosphorus is held in the sediments by an inorganic mechanism involving iron (Brydges, 1970).

Phosphorus in lake sediments tended to be higher in the Precambrian Shield lakes than in the Lowland lakes, with average values of 1.7 and 0.59 mg/gm in the two groups, respectively. The corresponding iron concentrations were 42 mg/gm in the Precambrian Shield lakes and 5.1 mg/gm in the Lowland lakes.

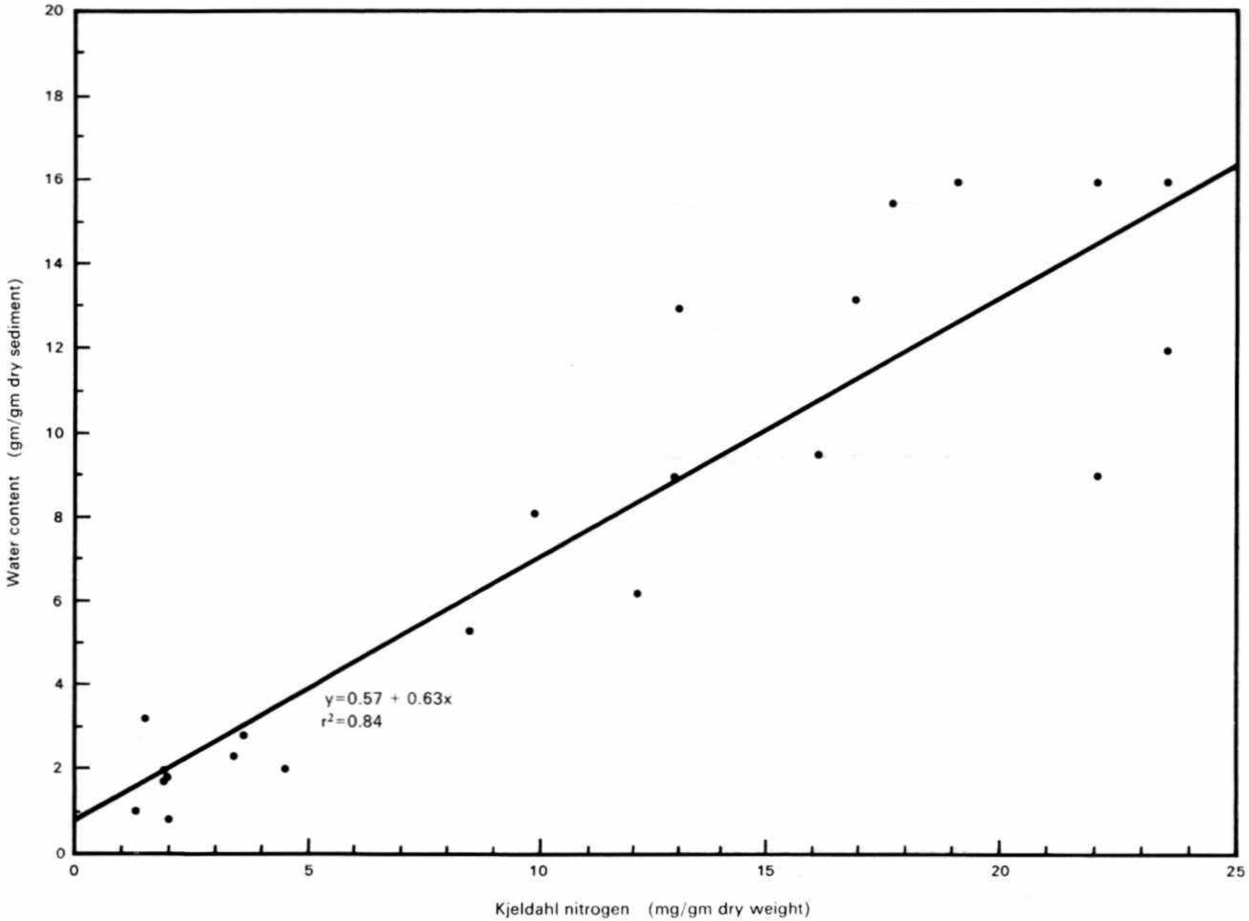

Figure 6. Water content vs. Kjeldahl nitrogen concentrations in the sediments of the study lakes.

The high concentrations of iron and phosphorus in the sediments of North Spirit and Wunnummin lakes do not seem to reflect the conditions in the lake waters, which were low in both elements in both lakes. Sandy Lake on the other hand, had high concentrations of both elements in the water and sediments. The high concentrations in the water were attributed to the inflow of the Flanagan River and the sediments presumably reflect this material settling out. Eight soil samples were collected from the banks of the Flanagan River that had average iron and phosphorus concentrations of 0.50 and 26 mg/gm, respectively. The Fe:P weight ratio of 52:1 compares well to the corresponding values of 43:1 for the Flanagan River and 45:1 and 52:1 in the top and bottom of Sandy Lake. The same weight ratio in the sediments of Sandy Lake was 36:1, which is in reasonable agreement considering it is based on a single sample while the other data are for several sets of analyses.

Total Manganese

Manganese concentrations in lake sediments varied from 0.19 to 9.7 mg/gm, with the higher values associated with high total iron content. This observation is consistent with results previously reported by Gorham and Swaine (1969), and Brydges (1970).

PHYTOPLANKTON POPULATIONS

A summary of the phytoplankton data obtained from 28 lakes during the summers of 1970 and 1971 is provided in Table 3. Pictorial representations of phytoplankton communities in

TABLE 3. SUMMARY OF PHYTOPLANKTON DATA

LAKE	No. of Samples	No. of Genera	Total No. of a.s.u.	Per cent of total a.s.u.			
				Blue-greens	Greens	Diatoms	Flagellates
Albany Basin							
Bog Lake	6	54	31,085	76.1	11.7	3.7	8.5
BlueGoose Lake	9	46	10,672	62.1	6.7	8.5	22.6
Bluejay Lake	9	33	661	23.8	15.1	44.2	16.9
Keezhik Lake	10	44	16,546	79.9	2.4	16.2	1.5
Lingen Lake	9	47	68,385	77.8	7.1	12.8	2.3
Lower Twin Lake	8	48	7,525	59.0	5.2	24.0	11.8
Lucy Lake	10	54	7,159	44.3	5.4	37.6	12.8
String Bog	8	48	3,399	8.4	15.7	2.5	73.4
Troutfly Lake	10	50	5,946	67.2	5.4	24.2	3.1
Wabimeig Lake	9	58	85,521	87.0	6.2	5.1	1.7
Attawapiskat Basin							
Attawapiskat Lake	10	53	2,939	42.2	4.5	35.3	18.0
Streatfield Lake	9	54	103,689	87.9	8.0	2.8	1.4
Moose Basin							
Brunswick Lake	8	42	9,077	66.0	5.7	11.5	16.8
Pierre Lake	8	45	6,030	49.6	5.0	33.2	12.3
Remi Lake	8	51	15,468	64.4	2.5	24.6	8.5
Saganash Lake	8	48	11,004	74.3	5.6	12.7	7.4
Shannon Lake	7	45	5,093	20.8	16.8	33.6	28.8

TABLE 3.

SUMMARY OF PHYTOPLANKTON DATA

LAKE	No. of Samples	No. of Genera	Total No. of a.s.u.	Per cent of total a.s.u. Blue-greens	Greens	Diatoms	Flagellates
Severn Basin							
Agusk Lake	10	52	51,545	94.0	2.9	2.5	0.6
Big Trout Lake	10	49	8,079	59.1	3.2	33.2	4.4
Big Trout Lake Bog	9	44	5,773	5.3	3.5	4.4	86.8
Kaness Lake	10	49	6,163	73.8	3.3	15.9	7.0
North Spirit Lake	10	42	6,310	68.4	3.0	11.7	17.0
Sandybank Lake	9	42	106,284	97.0	0.8	1.9	0.4
Winisk Basin							
Atikameg Lake	10	50	123,844	80.8	11.7	6.6	0.8
Kasabonika Lake	9	51	6,224	71.3	3.3	17.7	7.6
Shagamu Bog	7	46	12,542	85.1	4.2	1.3	9.4
Shagamu Lake	11	52	64,425	92.9	3.3	2.4	1.4
Wunnummin Lake	10	41	8,672	28.5	1.6	64.4	5.5

individual lakes are shown in Figures 7 to 34 of Appendix B (in alphabetical order according to lake name).

Agusk Lake (1970)

The phytoplankton population of Agusk Lake was extremely high throughout the summer reaching a maximum of 14,287 areal standard units per millilitre (a.s.u./ml) on August 3. The blue-green group dominated the phytoplankton population, largely due to the massive numbers generated by the genus *Aphanothece*. Greens, flagellates and diatoms were poorly represented.

Atikameg Lake (1971)

The phytoplankton population of Atikameg Lake was extremely high throughout the sampling period attaining its highest level of 22,891 a.s.u./ml on August 4. A massive blue-green bloom persisted throughout the sampling period, dominated by the genus *Aphanothece*. The green group was fairly well represented, with the genera *Pediastrum* and *Scenedesmus* being the major contributors to this group. The diatom and flagellate groups were poorly represented.

Attawapiskat Lake (1970)

Phytoplankton populations were low throughout the sampling period, reaching a maximum of 562 a.s.u./ml on July 20. The blue-green group contributed most of the total phytoplankton population, with the genus *Oscillatoria* being the most significant, although it did not strongly dominate this group.

The diatoms were the second most abundant group, making up 35% of the total phytoplankton population, with Melosira and Asterionella the most important genera. The flagellate group was well represented (18% of the total phytoplankton population) while the greens comprised only 5%.

Big Trout Lake (1970)

The phytoplankton population of Big Trout Lake was low to moderate throughout the sampling period, reaching a maximum of 1,222 a.s.u./ml on August 6. The blue-green group dominated this lake, making up 59% of the total phytoplankton population with the genus Aphanothece being the most significant. The diatoms were the second largest group making, up one third of the total phytoplankton population, with the genera Melosira and Stephanodiscus being the most significant. The flagellate and green groups were poorly represented, making up 4 and 3% of the total phytoplankton population, respectively.

Big Trout Lake Bog (1970)

The phytoplankton population was low throughout the sampling period, except for a flagellate bloom composed mostly of the genus Dinobryon during the last week of June and the first week of July. The highest phytoplankton population was recorded on July 5 when 2,006 a.s.u./ml was reported; of this, 1,980 a.s.u./ml was contributed by Dinobryon. The flagellates were the most significant group making up 87% of the total phytoplankton population. The blue-green, diatom, and green groups were poorly represented.

Blue Goose Lake (1971)

The phytoplankton population of Blue Goose Lake was moderate throughout the summer, reaching its highest level of 2,980 a.s.u./ml on August 28. The blue-green group, predominantly the genera Aphanothece and Microcystis, dominated the phytoplankton population. The flagellate group was well represented, making up nearly 25% of the total phytoplankton population, with Dinobryon being the most significant genera. The diatoms and greens were poorly represented.

Bluejay Lake (1971)

Phytoplankton levels were extremely low throughout the sampling period, reaching their highest value of 106 a.s.u./ml on July 27. The diatom group contributed the largest portion of the total phytoplankton of this lake, although each of the other three groups were well represented. The most significant genus of the diatom group was Cyclotella which was found consistently throughout the sampling period.

Bog Lake (1971)

The phytoplankton population of Bog Lake was high throughout the sampling period, attaining its maximum level of 8,426 a.s.u./ml on September 3. A massive bloom of blue-green algae persisted throughout the summer, largely comprised of the genus Aphanothece. The flagellates and greens were well represented. The most significant genus of the flagellate group was Dinobryon while the genera Oocystis and Scenedesmus were the major representatives of the green group.

Brunswick Lake (1971)

Phytoplankton populations were low in Brunswick Lake during June and July, but increased to a high of 3,392 a.s.u./ml on August 27. The blue-green group dominated the phytoplankton population mainly due to the genera Aphanothece and Lyngbya. The flagellate and diatom groups were well represented, making up 17 and 12% of the total population, respectively, while the greens made up only 6% of the total population.

Kaness Lake (1970)

Phytoplankton populations in Kaness Lake were low throughout the sampling period, reaching a maximum on July 20 (1,296 a.s.u./ml). The blue-green group dominated this lake, making up 74% of the total phytoplankton population, with the genera Anabaena and Aphanizomenon being the most important. The diatom and flagellate groups comprised 16 and 7% of the total phytoplankton population, respectively. The green group was poorly represented.

Kasabonika Lake (1970)

The phytoplankton population in Kasabonika Lake was low throughout the sampling period, reaching a maximum of 1,360 a.s.u./ml on July 31. The blue-green group dominated this lake, making up 71% of the total phytoplankton population with Aphanothece being the most significant genus. The diatom group made up 17% of the total population, with the genus Synedra being the most important. The flagellate and green groups comprised 8 and 3% of the total phytoplankton population, respectively.

Keezhik Lake (1970)

The phytoplankton population of Keezhik Lake was moderate to high throughout the summer, reaching a maximum value of 3,036 a.s.u./ml on September 25. Eighty percent of this maximum was contributed by the blue-green group, with *Aphanothece* and *Lyngbya* being the most important genera. The diatom group contributed 16% of the total phytoplankton population, with the genus *Melosira* being the most significant. The flagellate and green groups were insignificant.

Lingen Lake (1971)

Throughout the survey period a blue-green algae bloom existed, composed of very high levels of *Aphanothece* and *Lyngbya* that reached maximum values of 9,598 and 1,067 a.s.u./ml, respectively, on June 25. The blue-greens *Chroococcus*, *Aphanocapsa* and *Anabaena* were usually present at moderate levels. *Microcystis* exhibited a high population of 2,304 a.s.u./ml on July 15. Flagellates were present in low levels and values for greens were moderate throughout the sampling period. The diatoms were present at moderate to high levels, the dominant forms being *Tabellaria* and *Fragilaria* that attained their highest values of 2,286 and 1,683 a.s.u./ml on June 25 and September 3, respectively.

Lower Twin Lake (1971)

Phytoplankton populations in Lower Twin Lake were low to moderate throughout the sampling period, reaching their highest value of 1,527 a.s.u./ml on June 12. The blue-green group contributed 59% of the total phytoplankton population, with the genus Aphanothece, by itself, accounting for 19% of the total phytoplankton population. The diatom group was well represented, making up 24% of the total phytoplankton population, with the most significant genus being Melosira. The flagellates and greens comprised 12 and 5% of the total phytoplankton population, respectively.

Lucy Lake (1971)

Phytoplankton levels were low to moderate throughout the summer, reaching their maximum (1,484 a.s.u./ml) on September 15. The blue-green and diatom groups comprised the majority of the total phytoplankton of this lake. The most significant genera of the blue-green group were Aphanothece and Oscillatoria, which contributed 19 and 12%, respectively, of the total phytoplankton population. The most significant genera in the diatom group were Synedra and Melosira, contributing 19 and 8%, respectively, of the total phytoplankton.

North Spirit Lake (1970)

The phytoplankton population of North Spirit Lake was low throughout the sampling period, reaching a maximum of 1,605 a.s.u./ml on July 20. The blue-green group dominated the phytoplankton of this lake, comprising 68% of the total phytoplankton population, with the genus Aphanothece the most significant. The flagellate and diatom groups comprised 17 and 12%, respectively, of the population. The green group was insignificant, making up only 3% of the total phytoplankton population.

Pierre Lake (1971)

The phytoplankton population of Pierre Lake was low to moderate throughout the sampling period, reaching a maximum of 1,427 a.s.u./ml on August 17. Fifty percent of the total phytoplankton population was contributed by members of the blue-green group, with the genera Oscillatoria and Aphanizomenon being the most significant. The diatoms were the second largest group, making up one third of the total phytoplankton population, with Melosira being the most significant genus. The flagellate and green groups made up 12 and 5%, respectively, of the total phytoplankton population.

Remi Lake (1971)

The phytoplankton population of Remi Lake was moderate to high throughout the sampling period, reaching a maximum of 3,104 a.s.u./ml on August 17. The blue-green group dominated the phytoplankton population primarily due to the genera Aphanothece and Anabaena. The diatom group was well represented, making up 25% of the total population with Melosira and Asterionella being the most significant genera. The flagellates and greens made up 8 to 3% of the total phytoplankton population, respectively.

Saganash Lake (1971)

Phytoplankton levels in Saganash Lake were low in early summer but gradually increased to bloom conditions by August when they attained their highest level of 2,978 a.s.u./ml.

The blue-green group comprised nearly 75% of the phytoplankton population, with the genera Anabaena and Lyngbya being the major contributors. The diatom group was well represented, making up 13% of the phytoplankton population while the flagellate and green groups made up 7 and 6%, respectively.

Sandybank Lake (1970)

Sandybank Lake had extremely high phytoplankton levels throughout the sampling period, attaining its highest value (24,393 a.s.u./ml) on July 4. A massive blue-green bloom dominated the phytoplankton population, mostly attributable to the genus Aphanothece. The other three algal groups were poorly represented.

Shagamu Bog (1970)

The phytoplankton population of Shagamu Bog ranged from moderate to high, reaching a maximum of 4,332 a.s.u./ml on July 18, and then declining to low values in the fall. The blue-green group dominated, making up 85% of the total phytoplankton population. The blue-green dominance was largely attributable to the genus Aphanothece. Flagellates were well represented but only made up 10% of the total phytoplankton population throughout the sampling period due to the blue-green algae bloom during late July and early August. The green and diatom groups were poorly represented.

Shagamu Lake (1970)

Shagamu Lake had a low phytoplankton population in June, immediately after breakup, but quickly developed a large population that was maintained throughout the sampling period. The highest value recorded was 14,648 a.s.u./ml on August 3. A massive blue-green bloom developed early in July (primarily Aphanothece) and persisted throughout the summer and fall. The diatom, flagellate and green groups were insignificant.

Shannon Lake (1971)

Phytoplankton populations were moderate throughout the sampling period, attaining a maximum of 1,379 a.s.u./ml on September 28. All four groups were represented with no substantial dominance by any one group. The largest group was diatoms, with Fragilaria and Melosira being the most significant genera. The genus Dinobryon of the flagellate group comprised 19% of the total phytoplankton of Shannon Lake.

Streatfield Lake (1971)

The phytoplankton population of Streatfield Lake was extremely high throughout the sampling period, reaching its maximum (29,049 a.s.u./ml) on June 25. A massive blue-green bloom was present throughout the summer, primarily of the genera Aphanothece and Lyngbya. The flagellate group was fairly well represented, largely due to the genus Scenedesmus. The diatoms and flagellates were poorly represented.

String Bog (1971)

The phytoplankton population of the String Bog remained low throughout the sampling period, reaching a maximum of 691 a.s.u./ml on August 1. The flagellate group dominated the Bog, making up 73% of the total phytoplankton found throughout the sampling period. Unidentified genera comprised the majority of the flagellates, however, *Dinobryon* and *Chlamydomonas* were consistently present throughout the sampling period. The green group was well represented, making up 16% of the total phytoplankton population while the blue-green and diatom groups made up 8 and 2% of the phytoplankton population, respectively.

Troutfly Lake (1970)

Phytoplankton levels were low throughout the summer, gradually increasing in the fall when they reached their highest level of 1,638 a.s.u./ml (September 25). The blue-green group contributed the largest portion of the total phytoplankton population, followed in importance by the diatom group. The green and flagellate groups were poorly represented. The most significant genus in the blue-green group was *Aphanothece*, that made up 37% of the total phytoplankton population of this lake.

Wabimeig Lake (1971)

A blue-green bloom was present throughout the sampling period. The dominant forms were, in order of abundance, Aphanothece, Lyngbya, Chroococcus, and Anabaena. Aphanothece reached its highest level on August 14 when a count of 8,821 a.s.u./ml was recorded. Additionally, high levels of Microcystis and Aphanocapsa were reported, but their appearances in the phytoplankton population were sporadic. Populations of diatoms, flagellates and greens were moderate, the dominant forms being the diatom Tabellaria and the green algae Oocystis.

Wunnummin Lake (1970)

Phytoplankton populations in Wunnumin Lake were low to moderate throughout the sampling period, reaching maximum values on September 2, (1,855 a.s.u./ml). This lake was dominated by the diatom group which made up 64% of the total phytoplankton population. Melosira, Tabellaria and Asterionella were the most significant genera of the diatom group. The blue-green group made up 29% of the phytoplankton population, with the genus Aphanothece comprising almost half the total blue-green population. The flagellate and green groups were represented poorly.

CHARACTERISTICS OF LAKE GROUPS

On the basis of chemistry, morphology, and phytoplankton communities the 28 intensively studied lakes can be divided into 5 general groups (Table 4). These groups, discussed below, represent the basic lake types occurring in the Arctic Watershed of Ontario.

GROUP I - PRECAMBRIAN SHIELD

Bluejay, Troutfly and Lucy lakes:

These three lakes exhibited characteristics of marl lakes, which are typified by high bicarbonate alkalinity, high calcium concentrations and marked deposits of calcium carbonate. Concentrations of phosphorus and nitrogen were low and correspondingly phytoplankton densities were low. All three lakes exhibited a dominant blue-green and diatom association which is typical of hard-water lakes.

These three lakes are within the Precambrian Shield area of the Albany River system. They are all situated in outwash deposits of sands and gravels in esker and delta complexes. Bluejay, Lucy and Troutfly lakes are fairly small and deep, covering areas of less than 1, 10, and 13 km^2, respectively, with mean depths ranging from 6 to 9 m. They are relatively undeveloped lakes, having only a few camp sites. Lucy and Bluejay lakes are accessible by road, while Troutfly Lake is accessible only by aircraft.

Each lake appeared bright blue-turquoise in colour. All had very low readings for colour and turbidity, usually approaching

TABLE 4. GROUPINGS OF THE TWENTY-EIGHT SELECTED LAKES

	Precambrian Shield			Hudson & James Bay Lowland	
Basin	Group I	Group II	Group III	Group IV	Group V
Albany	Bluejay L.[1] Lucy L. Troutfly L.	Keezhik L. Lower Twin L.	-	String Bog	Blue Goose L.[1] Bog L. Lingen L. Wabimeig L.
Attawapiskat	-	-	Attawapiskat L.	-	Streatfield L.
Moose	-	Brunswick L. Remi L. Saganash L. Shannon L.	Pierre L.	-	-
Severn	-	-	Big Trout L. Kaness L. North Spirit L.	Big Trout Lake Bog[2]	Agusk L. Sandybank L.[2]
Winisk	-	-	Kasabonika L. Wunnummin L.	Shagamu Bog	Atikameg L. Shagamu L.

1. Grouping based on water quality and phytoplankton populations; exact locations in relation to the Shield/Lowland boundary are difficult to ascertain.

2. Grouping based on water quality, phytoplankton populations and general surroundings; actual locations are on the Precambrian Shield.

zero. Secchi disc readings were correspondingly high. Median values for total hardness (as $CaCO_3$) were high - 238 mg/l for Bluejay Lake, 113 mg/l for Lucy Lake, and 100 mg/l for Troutfly Lake. White sediment was present in some areas on the bottom of all these lakes, apparently resulting from the settling or precipitation of calcium carbonate from the overlying waters. Strong thermal stratification did not occur at Lucy or Troutfly lakes, nor were the bottom waters seriously depleted of dissolved oxygen. At Bluejay Lake a good thermocline did develop in June which lasted through September when the dissolved oxygen declined to 2.2 mg/l in the bottom waters.

The blue-greens always comprised the greatest percentage of the phytoplankton flora, except at Bluejay Lake where the diatoms predominated. This can be correlated with the high median silica value 10.3 mg/l recorded for Bluejay Lake. The phytoplankton population was quite diverse, with the flagellates and greens well represented in most cases.

GROUP II - PRECAMBRIAN SHIELD

Lower Twin, Remi, Brunswick, Saganash, Shannon and Keezhik lakes

All six lakes of this group exhibited the blue-green and diatom association typical of moderately hard-water lakes. The phytoplankton flora was rich and diversified, with each of the phytoplankton groups being well represented in each lake. The blue-greens however, were always the dominant group, with the exception of Shannon Lake where diatoms were dominant. Small phytoplankton blooms occurred at Remi, Brunswick, Keezhik and Saganash lakes. This can be correlated with the higher phosphorus concentrations in these lakes as compared to those found at Lower Twin and Shannon lakes where blooms did not occur.

All of these lakes are in the Precambrian Shield area of the Hudson and James Bay drainage basin. Remi, Brunswick, Saganash and Shannon lakes are situated in areas covered by ground moraines composed mostly of clayey tills. Keezhik and Lower Twin lakes are located in areas covered by ground and end moraines composed of sandy till, sand and gravel. All of these lakes have mean depths of between 3 and 6 m with the exception of Shannon Lake which has a mean depth of less than 2 m. Surface areas range in size from 12 km^2 at Lower Twin Lake to 54 km^2 at Keezhik Lake. Remi and Lower Twin lakes are easily accessible by road and have cottages and tourist camps on their shores. Saganash and Shannon lakes are accessible by logging roads in the summer and snowmachines in the winter. They are relatively undeveloped, although Saganash Lake is used extensively by local fishermen. Brunswick and Keezhik lakes are accessible only by aircraft and are completely undeveloped.

Water colour and turbidity were low to moderate giving them the appearance of fairly clear water lakes. Median hardness values ranged from 67 mg/l for Keezhik Lake to 87 mg/l for Remi Lake. Median total nitrogen values ranged from .27 mg/l for Keezhik Lake to .48 mg/l at Brunswick Lake. Median total phosphorus values ranged from .010 mg/l for Lower Twin Lake to .021 mg/l for Brunswick Lake. Secchi disc readings ranged from 1.1 to 1.5 m for Saganash Lake to 1.8 to 3.8 m at Keezhik Lake. Well defined thermoclines did not develop in any of these lakes, nor was there any sign of dissolved oxygen depletion in the bottom waters throughout the sampling period.

GROUP III - PRECAMBRIAN SHIELD

Attawapiskat, Big Trout, Wunnummin, Pierre, North Spirit, Kaness (Roseberry) and Kasabonika (Shibogama) lakes

The waters of this group of lakes were generally soft and nutrient poor, some being slightly humic and having high water color. The phytoplankton flora of each lake was similar, being dominated by blue-greens, with diatoms and occasionally flagellates making up a significant part of the total. The greens and at times flagellates, were insignificant. Phytoplankton populations remained low throughout the sampling period, which was attributable to the low nutrient values.

These seven lakes are situated on the Precambrian Shield, in areas covered by thin till plains and outwash deposits. Mean depths range from 3 to 10 m, with surface areas varying from 5 km^2 at Kaness Lake to 650 km^2 at Big Trout Lake.

GROUP IV - LOWLAND

Big Trout Lake Bog, String Bog and Shagamu Bog

These three bogs were generally soft, nutrient poor, humic waters. They supported a flagellate flora predominantly comprised of the genus *Dinobryon*, although at Shagamu Bog this was masked by a short massive bloom of the blue-green genus *Aphanothece*.

These three bodies of water are all typical small, shallow bog ponds of the Hudson and James Bay Lowland. Each of them covers less than 0.5 km^2 and has a mean depth of less than 1 m. There is little or no drainage pattern connected with these bogs, indicating that these waters are maintained either by direct precipitation or seepage from the surrounding muskeg. These ponds are used only by wildlife in the area or possibly the occasional hunter; they support no fish population.

The basins of String Bog and Shagamu Bog are formed almost completely of peat allowing water very little or no interaction with the soil below the peat layer. As a result, median hardness values (as $CaCO_3$) were low (6.5 and 24 mg/l, respectively). Part of the bottom of Big Trout Lake Bog is clayey till and the median hardness value was correspondingly higher (63 mg/l). Owing to their small size, wind action has little mixing effect. Consequently, median turbidity readings were low. Median water colour readings were high, and correspondingly, high levels of tannins and lignins were recorded at each bog. Median values for phosphorus were low while median values for Kjeldahl nitrogen were high. Due to the shallow nature of these bogs, Secchi disc readings extended to the bottom of the bogs. The dissolved oxygen remained high throughout the summer, varying according to water temperature.

GROUP V - LOWLAND

Agusk (Teepeestick), Bog, Sandybank, Shagamu, Atikameg, Streatfield, Lingen, Wabimeig, and Blue Goose lakes

This group was typified by nutrient rich, soft-water lakes that were dominated by massive blooms of blue-green algae from early summer to late fall. The most significant genus of the blue-green group was Aphanothece. In general, flagellates played an insiginificant role in the phytoplankton flora while the diatoms and greens were present at low to moderate levels.

These are typical shallow lakes of the Hudson and James Bay Lowland. Mean depths of all are less than 2 m, while surface areas range from 4 km^2 at Bog Lake to 48 km^2 at Wabimeig Lake. All of these lakes, with the exception of Blue Goose Lake, are surrounded with muskeg and their drainage patterns are usually poorly developed. Most of the water in these lakes is from direct precipitation or seepage from the surrounding muskeg. They are completely undeveloped and used by only local wildlife and the occasional hunter or fisherman.

All of the lakes appeared dark brown in colour, usually having high colour and turbidity values. The bottom sediments were dark brown or black and this, combined with the shallow water, intensified the dark brown appearance of these lakes. The high surface area to volume ratio of these lakes and the sparse, rather short, trees of the surrounding muskeg allow wind action to thoroughly mix them. At times, the lakes were so turbid with suspended sediments, peat and debris that it was difficult to collect and count phytoplankton samples or take Secchi disc readings. Hardness values ranged from a low of 11.5 mg/l for Bog Lake to 47 mg/l for Blue Goose Lake. This is likely a reflection of variation in the amount of circulation the water of each lake has with soils beneath the muskeg or peat basins that contain them. Little or no thermal stratification occurred and dissolved oxygen readings fluctuated with water temperature.

SUMMARY

As part of the Northern Ontario Water Resources study, water quality data were collected from selected lakes in the five major river basins (Moose, Albany, Attawapiskat, Winisk, and Severn) that drain into Hudson and James Bay. Twenty-eight of the lakes were sampled intensively, and on the basis of lake morphology, water chemistry and phytoplankton populations they were divided into five general groups.

Three of the groups, consisting of a total of sixteen lakes, encompass the general characteristics of lakes on the northern Ontario Precambrian Shield. One group, consisting of three bogs, and another group, consisting of nine lakes, illustrate the general characteristics of bogs and lakes on the Hudson and James Bay Lowland.

Big Trout Lake Bog and Sandybank Lake, located on the Precambrian Shield, are grouped under lakes on the Lowland since their water chemistry and phytoplankton populations were similar to other bogs and lakes in this category. Exact locations of Bluejay and Blue Goose Lakes in relation to the Precambrian Shield/Lowland boundary are difficult to ascertain and their groupings may not reflect the geographic locations of these two lakes.

The general characteristics of the five groups that represent the basic lake types in the northern Ontario study area are as follows:

Group I - Precambrian Shield; Bluejay, Troutfly and Lucy lakes.

Small deep lakes; mean depth greater than 5 m; alkalinity greater than 100 mg/L; high Secchi disc values (greater than 5 m); phytoplankton population dominated by blue-greens and diatoms; nutrient poor waters.

Group II - Precambrian Shield; Lower Twin, Remi, Brunswick, Saganash, Shannon and Keezhik lakes.

Various size lakes; mean depth greater than 2 m; alkalinity 60 to 100 mg/L; moderate Secchi disc transparency (1 to 4 m); phytoplankton population dominated by blue-greens and diatoms; moderate to high nutrient concentrations.

Group III - Precambrian Shield; Attawapiskat, Big Trout, Wunnummin, Pierre, North Spirit, Kaness and Kasabonika lakes.

Various size lakes; mean depth greater than 3 m; alkalinity less than 60 mg/L; Secchi disc transparency 1 to 6 m; phytoplankton population dominated by blue-greens with diatoms usually well represented; nutrient poor waters.

Group IV - Lowland; Big Trout Lake Bog, String Bog and Shagamu Bog.

Small shallow lakes; mean depth less than 1 m; alkalinity less than 60 mg/L; Secchi disc visible to bottom; phytoplankton population dominated by flagellates; nutrient poor humic waters.

Group V - Lowland; Agusk, Bog, Sandybank, Shagamu, Atikameg, Streatfield, Lingen, Wabimeig, and Blue Goose lakes.

Various size lakes; mean depth less than 2 m; alkalinity less than 60 mg/L; Secchi disc at times visible to bottom; phytoplankton population dominated by blue-greens; nutrient rich waters.

The most obvious difference between lakes on the Precambrian Shield and lakes on the Hudson and James Bay Lowland is their alkalinity. The alkalinity of lakes on the Hudson and James Bay Lowland was unexpectedly low, while that of lakes on the Precambrian Shield of northern Ontario was surprisingly high, in comparison to lakes on the Precambrian Shield of south-central Ontario.

The high alkalinities reported for the lakes on the Precambrian Shield in the Arctic Watershed appear to result from contact with the relatively thick unconsolidated overburden that covers most of the drainage basins. The low alkalinities observed in the Lowland lakes, in an area of limestone and dolomite bedrock, are apparently attributable to the almost continuous surface layer of peat on the Lowland. This peat layer apparently prevents or reduces the interaction of water with the overburden and bedrock materials in the drainage basins of the Lowland lakes, resulting in the unexpectedly low alkalinity values.

The lake groups derived herein reflect the water quality and phytoplankton populations of the lakes, as they are influenced by the geology of the drainage basins and the morpology of the lake basins. Although the groupings are artificial boundaries on a system that grades from the extremes, the classification provides a convenient framework for discussing data on lakes in the Arctic Watershed of Ontario.

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APPENDIX A

MOE Bulletin References to Water Quality Sampling Locations

The following list serves as a cross-reference between the sources of the samples and the Bulletins in which the water quality data can be found. The twenty-eight intensively studied lakes are underscored in this list for ease of reference. The sample location numbers shown on Map 1 and listed in this Appendix do not appear in the bulletins; cross-referencing must be made by the source of the sample and its longitude and latitude. The following are the pertinent Bulletins:

Ontario Water Resources Commission, 1969, Water Resources Bulletin 1-1, Data for Northern Ontario Water Resources Studies, 1966 to 1968.

________________________________, 1970, Water Resources Bulletin 1-2, Data for Northern Ontario Water Resources Studies, 1968 to 1969.

________________________________, 1972, Water Resources Bulletin 1-3, Data for Northern Ontario Water Resources Studies, 1970.

Ministry of the Environment, 1973, Water Resources Bulletin 1-4, Data for Northern Ontario Water Resources Studies, 1971.

__________________________, 1975, Water Resources Bulletin 1-5, Data for Northern Ontario Water Resources Studies, 1972-1973.

General:

(1) Locations shown on Map 1 are for ease of reference and are accurate within the limits of normal plotting errors;

(2) for any one sample location, small variations in longitudes and latitudes may exist from bulletin to bulletin.

Corrections:

(1) Location 42-06-30 is listed in Bull. 1-5 as Opasatika River, 49° 05' N, 82°55' W; the correct latitude is 49°35'.

(2) Location 43-06-33 is listed under the Moose River basin in Bull. 1-4; its correct location is in the Albany River basin.

(3) Location 43-06-34 is listed under the Moose River basin in Bull. 1-4; its correct location is in the Albany River basin.

(4) Location 43-06-43 is listed under the Moose River basin in Bull. 1-3 and 1-4; its correct location is in the Albany River basin.

(5) Location 46-06-14 is listed as Shibogama Lake in Bull. 1-3; the correct source of sample is Kasabonika Lake.

(6) Location 46-06-27 is listed in Bull. 1-3 as Wunnummin Lake, 52° 55' N, 89° 15' W and in Bull. 1-4 under Severn River basin; the correct location is 53° 38' N and 85° 35' W in the Winisk River basin.

Location Number Shown On Map 1	Source of Sample	Latitude North	Longitude West	Refer to Bulletin Number(s)
MOOSE RIVER BASIN				
42-06-01	Creek near Moosonee Airport	51°16'	80°39'	1-5
-02	Creek 2 mi. W. of Moosonee	51 17	80 42	1-5
-03	Creek 5 mi. W. of Moosonee	51 19	80 51	1-5
-04	Moose R. near Hudson Bay Dock	51 16	80 39	1-5
-05	Stringer L.	50 11	80 53	1-5
-06	Moose R. at Abitibi	51 05	80 56	1-5
-07	Abitibi R. at Onakawana R.	50 36	81 25	1-3,1-4,1-5
-08	Pierre L.	49 31	80 44	1-4, 1-5
-09	Driftwood R.	48 33	80 44	1-5
-10	Green L.	48 35	80 48	1-5
-11	Black R.	48 33	80 27	1-5
-12	Frederick House R.	48 50	81 00	1-5
-13	Slab L.	48 35	80 52	1-5
-14	Moose R. at Moose R.	50 49	81 18	1-3,1-4,1-5
-15	Mattagami R. at Smoky Falls	50 05	82 10	1-5
-16	Remi L.	49 25	82 10	1-4,1-5
-17	Kapuskasing R. at Kapuskasing	49 25	82 26	1-3,1-4,1-5
-18	Saganash L.	49 04	82 35	1-4,1-5
-19	Nemegosenda R.	47 04	83 04	1-5
-20	Side Burned L.	47 48	83 38	1-5
-21	Groundhog R. at Hwy. 11	49 21	82 03	1-5
-22	Ivanhoe L.	48 12	82 30	1-5
-23	Opishing L.	48 15	81 49	1-5
-24	Tatachikadika R.	48 19	81 35	1-5
-25	Kenogamissi L.	48 00	81 33	1-5
-26	Minisisinakwa L.	47 40	81 50	1-5
-27	Mesomikenda L.	47 55	81 58	1-5
-28	Campbell L.	50 18	82 13	1-5
-29	Missinaibi R.	50 28	82 15	1-1
-30	Opasatika R.	49 35	82 55	1-5
-31	Missinaibi R.	50 14	82 53	1-1
-32	Lac Ste. Therese	49 48	83 39	1-3
-33	Shannon L.	49 47	83 23	1-4,1-5
-34	Missinaibi R. at Mattice	49 37	83 16	1-3,1-4,1-5
-35	Brunswick L.	49 00	83 23	1-4,1-5
-36	Kesagami L.	50 28	80 15	1-5
-37	Marquis L.	49 54	80 10	1-5

Location Number Shown On Map 1	Source of Sample	Latitude North	Longitude West	Refer to Bulletin Number(s)
ALBANY RIVER BASIN				
43-06-01	Albany R.	$52^{\circ}14'$	$81^{\circ}35'$	1-1
-02	Albany R. at Fort Albany	52 16	81 40	1-5
-03	Lake S. of Yellow Cr., Fort Albany	52 11	81 42	1-5
-04	Yellow Cr.	52 11	81 42	1-5
-05	Pond-Fort Albany Radar Stn.	52 11	81 41	1-5
-06	Jaab L.	51 10	82 58	1-1
-07	Albany R. at Big Island	52 10	81 53	1-2
-08	Albany R.	52 03	82 22	1-1
-09	Albany R.	51 57	82 32	1-1
-10	Albany R.	51 48	83 04	1-1
-11	Cheepay R. or Chipie R.	51 27	83 26	1-1,1-2,1-3,1-4
-13	Pledger L.	50 53	83 42	1-1
-14	Albany R.	51 17	83 58	1-1
-15	Albany R.	51 09	84 26	1-1
-16	Creek-No Name	51 04	84 35	1-1
-17	Kenogami R.	50 58	84 36	1-1,1-2,1-3,1-4,1-5
-18	Howard Cr.	50 11	86 43	1-2
-19	Rounds L. at Nakina	50 11	86 44	1-2
-20	Balkam L.	50 11	86 45	1-2
-21	Balkam Cr.	50 11	86 40	1-1,1-2,1-3,1-4,1-5
-22	Minnow L.	50 11	86 41	1-5
-23	Queenston L.	50 24	86 44	1-1
-24	Percy L.	50 40	86 35	1-1
-25	Superb L.	50 30	87 00	1-1
-26	O'Sullivan L.	50 25	87 00	1-5
-27	Lucy L.	50 18	87 13	1-4,1-5
-28	Kawashkagama R.	50 26	87 09	1-1,1-2,1-3,1-4,1-5
-29	Lower Twin L.	50 10	86 31	1-4,1-5
-30	Upper Twin L.	50 08	86 37	1-1
-31	Ridge R.	50 28	83 54	1-1
-32	Kabinakagami R.	50 22	84 18	1-1
-33	Bluejay L.	50 02	84 08	1-1,1-4,1-5
-34	Blue Goose L.	50 00	84 08	1-4,1-5
-35	Constance L.	49 48	84 09	1-1
-36	Kabinakagami R. at Hwy. 11	49 44	84 06	1-1,1-5
-37	Irish L.	49 42	84 05	1-1
-38	Forde L.	49 44	84 15	1-1
-39	St. Joseph L.	49 47	84 02	1-1
-40	Valentine R.	49 44	84 01	1-1
-41	Pitopiko R.	49 46	84 46	1-1
-42	Skunk R.	49 45	84 29	1-1
-43	Shekak R. at Hwy. 11	49 45	84 24	1-1,1-3,1-4,1-5
-44	Nassau L.	49 40	84 16	1-1
-45	Arnott L.	49 36	84 36	1-1

Location Number Shown On Map 1	Source of Sample	Latitude North	Longitude West	Refer to Bulletin Number(s)
ALBANY RIVER BASIN (cont)				
43-06-46	Nagagamisis L.	49°28'	84°40'	1-1
-47	Government L.	49 12	84 53	1-1
-48	Pagwachuan R.	50 12	84 44	1-1
-49	Pagwachuan R.	50 01	85 14	1-1
-50	Pagwachuan L.	49 44	86 08	1-5
-51	Flint R.	50 03	85 37	1-1,1-2
-52	Klotz L.	49 48	85 52	1-1
-53	Kenogami R.	50 04	85 47	1-1
-54	Albany R.	51 24	85 03	1-1
-55	Muskwabik R.	51 32	85 05	1-1,1-2,1-3,1-4,1-5
-56	Lorenz L.	51 54	85 18	1-5
-57	Lingen L.	51 55	85 15	1-4,1-5
-58	Albany R.	51 32	85 12	1-1
-59	Albany R.	51 37	85 35	1-1
-60	Wabimeig L.	51 28	85 35	1-1,1-4,1-5
-61	Bog L.	51 29	85 43	1-4,1-5
-62	String Bog	51 31	85 44	1-4,1-5
-63	Ogoki R.	50 53	86 49	1-1
-64	Seseganaga L.	50 00	90 28	1-1
-65	Moberley L. or Brightsand R.	49 34	90 35	1-1,1-2,1-3,1-4,1-5
-67	Albany R.	51 42	86 00	1-1
-68	Opichuan R.	51 40	87 46	1-1,1-2,1-3,1-4,1-5
-69	Albany R.	51 23	87 48	1-1
-70	Attwood R.	51 16	88 17	1-1
-71	Attwood R.	51 15	88 30	1-1
-72	Eabamet R.	51 31	87 52	1-1,1-2
-73	Albany R. at Petawanga L.	51 29	88 25	1-2
-74	Albany R.	51 33	88 33	1-3,1-4,1-5
-75	Keezhik L.	51 45	88 30	1-3,1-4,1-5
-76	Troutfly L.	51 42	88 53	1-1, 1-3,1-4
-77	Miminiska L.	51 35	88 37	1-1
-78	Albany R.	51 29	88 59	1-1
-79	Lake - No Name	51 28	89 03	1-1
-80	Albany R.	51 30	89 03	1-1
-81	Albany R.	51 22	89 26	1-1
-82	Albany R. at Achapi L.	51 13	89 36	1-5
-83	Pashkokogan R.	51 02	90 12	1-1,1-2,1-3,1-4,1-5
-84	Pashkokogan L.	51 01	90 16	1-1
-85	McCrea L.	50 52	90 16	1-5
-86	Miniss L.	50 48	90 53	1-5
-87	St. Rapheal L.	50 45	91 11	1-5
-88	Cat R.	51 11	91 36	1-1,1-2,1-3,1-5
-89	Wesleyan L.	51 12	91 38	1-1
-90	Cat L.	51 45	91 50	1-5
-91	White Stone L.	51 57	91 58	1-5

Location Number Shown On Map 1	Source of Sample	Latitude North	Longitude West	Refer to Bulletin Number(s)
ATTAWAPISKAT RIVER BASIN				
44-06-01	Attawapiskat R.	52°58'	82°25'	1-5
-02	Mississa L.	52 18	85 12	1-1,1-5
-03	Attawapiskat R. below Muketei R.	53 06	85 05	1-3,1-4,1-5
-04	Streatfield L.	52 08	85 55	1-4,1-5
-05	Attawapiskat L.	52 15	87 55	1-3,1-4,1-5
-06	Pineimuta R. at Pineimuta L.	52 18	88 45	1-3,1-4,1-5
-07	Otoskwin R. below Badesdawa L.	51 49	89 36	1-4,1-5
-08	Lysander Cr.	51 51	89 41	1-1
-09	Badesdawa L.	51 39	89 57	1-1
-10	Menako L.	52 03	90 08	1-5
-11	Bow L.	51 37	90 15	1-5
-12	Dobie R.	51 37	90 32	1-1
EKWAN RIVER BASIN				
45-06-01	Ekwan R.	53 35	84 25	1-1,1-5
-02	Nowashe L.	53 45	83 10	1-5
-03	Boulanger L.	54 40	83 15	1-5
-04	Brant R.	55 05	82 32	1-5
-05	Sutton L.	54 30	84 45	1-5
WINISK RIVER BASIN				
46-06-01	Winisk R.	55 16	85 12	1-2
-02	Winisk R. at Winisk	55 28	85 10	1-5
-03	Loon L.	54 50	85 26	1-3,1-5
-04	Shamattawa R. & Shamattawa L.	54 12	85 41	1-2,1-5
-05	Shagamu Bog or Shagamii Bog	55 04	87 05	1-3,1-4,1-5
-06	Winisk R. at Pikwaknud Cr.	54 44	87 17	1-2,1-5
-07	Hill L.	54 34	87 22	1-3,1-5
-08	Winisk R. below Asheweig R.	54 31	87 14	1-4,1-5
-09	Hook L.	54 37	86 56	1-3,1-5
-10	Atikameg L.	54 15	88 22	1-3,1-4,1-5
-11	NOWRS Bog	54 14	88 23	1-3,1-5
-12	Ghost L.	54 38	87 30	1-5
-13	Asheweig R. at Straight L.	53 43	87 57	1-1,1-3,1-4,1-5
-14	Kasabonika L.	53 35	88 30	1-3,1-4,1-5
-16	Longdog L.	53 26	89 12	1-2
-17	Kingfisher L.	53 03	89 48	1-2
-18	Winisk R.	54 02	87 06	1-2
-19	Winisk R.	54 03	87 05	1-1
-20	Winisk L.	52 59	87 22	1-1,1-5
-21	Winisk L.	52 59	87 16	1-2
-22	Fishbasket R.	52 40	87 53	1-1
-23	Mameigwess L.	52 34	87 54	1-2
-24	Wapikopa L.	52 56	88 10	1-2
-25	Peeagwon Cr.	52 47	88 41	1-1

Location Number Shown On Map 1	Source of Sample	Latitude North	Longitude West	Refer to Bulletin Number(s)
WINISK RIVER BASIN (cont)				
46-06-26	Peeagwon L.	52°23'	88°49'	1-2
-27	Wunnummin L.	53 38	88 35	1-3,1-4,1-5
-28	Misamikwash L.	53 01	89 56	1-2
-29	Pipestone R. at Karl L.	52 34	90 14	1-4,1-5
-30	Mawley L.	52 21	90 47	1-2
-31	Horseshoe L.	52 20	90 44	1-5
-32	Morris R.	52 00	91 03	1-1
-33	Obabika L.	51 52	90 55	1-2
-34	Hudson Bay L.	55 52	86 49	1-3,1-5
-35	I.E.O. Lake	55 20	86 36	1-3,1-5
-36	Fog L.	55 14	86 36	1-3,1-5
-37	Shagamu L. or Shagamii L.	55 04	87 03	1-3,1-4,1-5
-38	Shell L.	55 15	87 20	1-5
SEVERN RIVER BASIN				
47-06-01	Severn R.	55 59	87 38	1-2
-02	Severn R. at Beaver R.	55 59	87 52	1-5
-03	Beaver R.	55 56	87 57	1-1
-04	Harvey L.	55 38	88 21	1-3,1-5
-05	Severn R.	55 27	88 09	1-2
-06	Severn R.	55 24	88 16	1-2
-07	Severn R. at Limestone Rapids	55 23	88 19	1-1,1-3,1-4,1-5
-08	Fawn R.	55 19	88 21	1-2
-09	Sayer L.	55 00	87 45	1-3,1-5
-10	Otter L.	54 11	88 55	1-3,1-5
-11	Sandybank L.	53 50	89 45	1-1,1-3,1-4,1-5
-12	Big Trout Lake Bog	53 51	89 53	1-3,1-4,1-5
-13	Big Trout L.	53 45	90 00	1-1,1-2,1-3,1-4,1-5
-14	Mishwamakan R.	53 40	90 07	1-1
-15	Fawn R.	53 47	90 32	1-1
-16	J.E.N. Lake	55 13	87 50	1-5
-17	Severn R.	55 05	88 59	1-1,1-2
-18	Sachigo R. at Blackbear R.	54 59	89 38	1-5
-19	Blackbear R.	54 25	90 18	1-1
-20	Sachigo R.	54 05	92 08	1-1
-21	Sachigo Lake Outlet	54 00	92 09	1-2
-22	Sachigo L.	53 50	92 00	1-2,1-5
-23	Morrison R.	53 48	91 50	1-1,1-2,1-3
-25	Sachigo R.	53 42	92 17	1-1,1-2,1-3
-26	Agusk L. or Teepeestick L.	54 39	89 30	1-2,1-3,1-4,1-5
-27	Dog L.	54 35	89 36	1-3,1-5
-28	Severn L.	53 51	90 52	1-5
-29	Makoop R.	53 45	90 55	1-1
-30	Makoop R.	53 41	90 55	1-1

Location Number Shown On Map 1	Source of Sample	Latitude North	Longitude West	Refer to Bulletin Number(s)
SEVERN RIVER BASIN				
47-06-31	Schade R.	53°33'	91°09'	1-1,1-2,1-3,1-4,1-5
-32	Michikan L.	53 55	90 58	1-2
-33	Two Rivers L.	53 48	91 32	1-2
-34	Muskrat Dam L.	53 26	91 41	1-2
-35	Severn R.	53 21	91 46	1-2
-36	Nikip L.	52 52	91 56	1-2,1-5
-37	Weagamow L.	52 56	91 17	1-2
-38	North Caribou L.	52 48	90 36	1-2,1-5
-39	Kishikas L.	52 08	91 56	1-2
-40	Windigo L.	52 35	91 32	1-1
-41	Windigo L.	52 33	91 33	1-2
-42	Roseberry L. or Kaness L.	52 37	92 31	1-3,1-4,1-5
-43	Mattson L.	52 19	92 47	1-2
-44	Sandy L.	53 02	93 00	1-1,1-4,1-5
-45	Setting Net L.	52 46	93 37	1-5
-46	Flanagan R.	52 49	93 27	1-1,1-2,1-3,1-4,1-5
-47	Mechita L.	52 39	93 24	1-5
-48	Cellist L.	52 39	93 11	1-5
-49	Pakwan L.	52 32	93 08	1-5
-50	North Spirit L.	52 31	93 01	1-2
-51	North Spirit L.	52 30	92 55	1-3,1-4,1-5
-52	Margot L.	52 32	93 15	1-5
-53	Hewitt L.	52 23	92 55	1-5
-54	Sandy L.	53 02	93 17	1-1,1-3,1-5
-55	Sandy L.	53 03	92 20	1-2
-56	South Trout L.	52 53	93 42	1-2
-57	Opasquia L.	53 17	93 36	1-2
-58	Favourable L.	52 56	93 54	1-2
-59	Deer L.	52 38	94 05	1-1,1-2,1-5

APPENDIX B

Temporal variation in phytoplankton populations in the study lakes. Figures 7 to 34 (in alphabetical order by lake name)

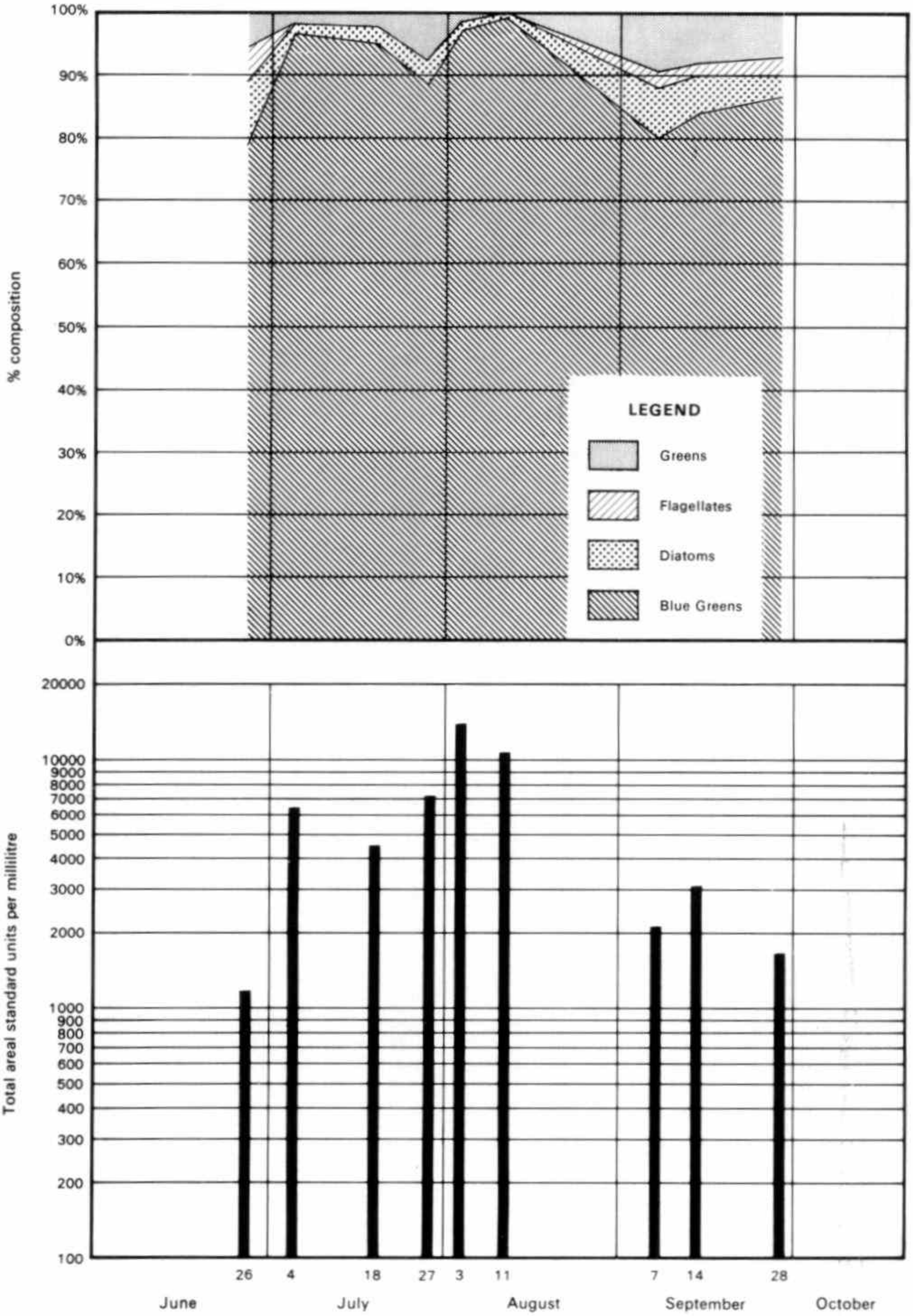


Figure 7. Phytoplankton stocks and composition in the euphotic zone of Agusk Lake during the ice-free period of 1970.

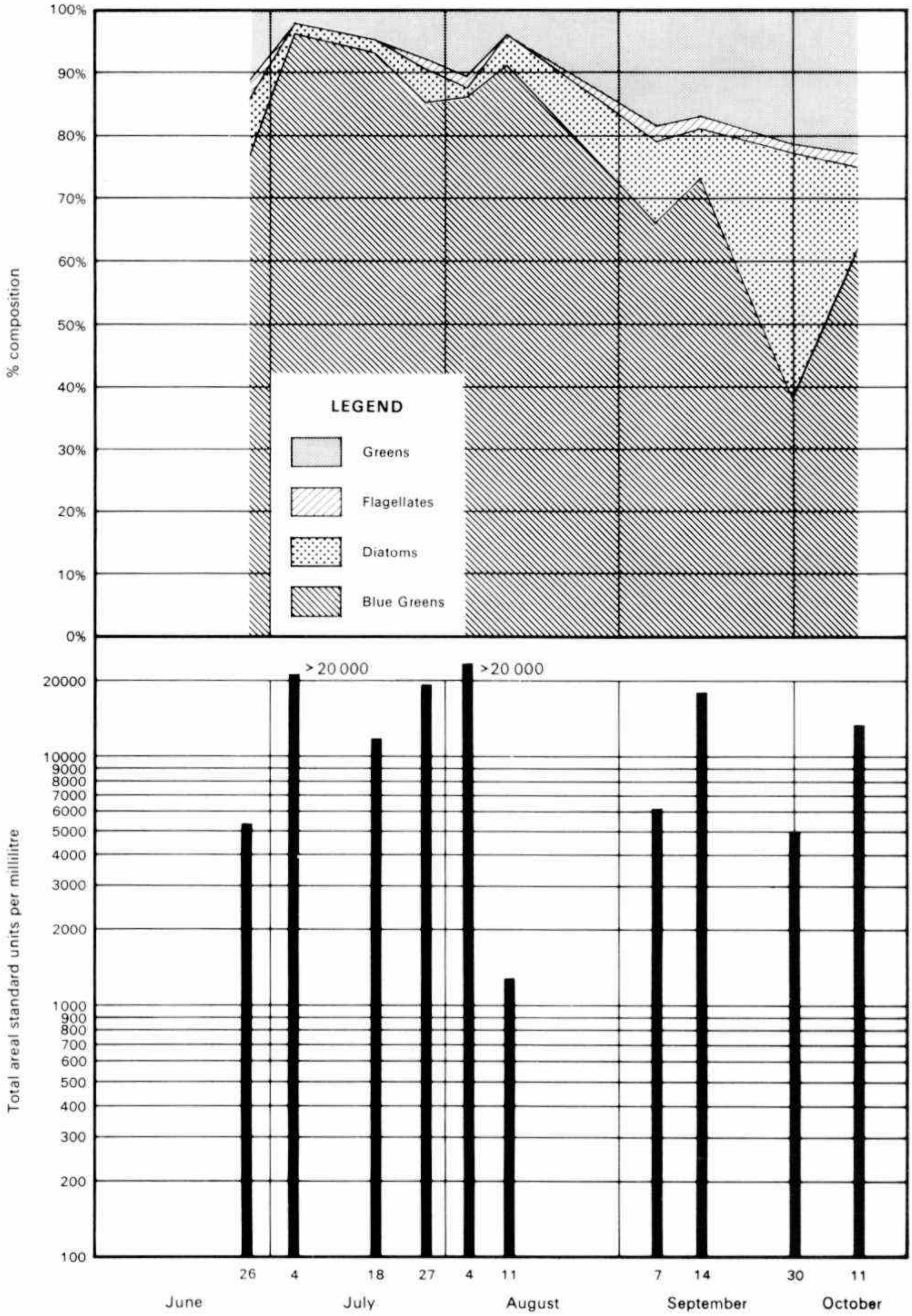


Figure 8. Phytoplankton stocks and composition in the euphotic zone of Atikameg Lake during the ice-free period of 1970.

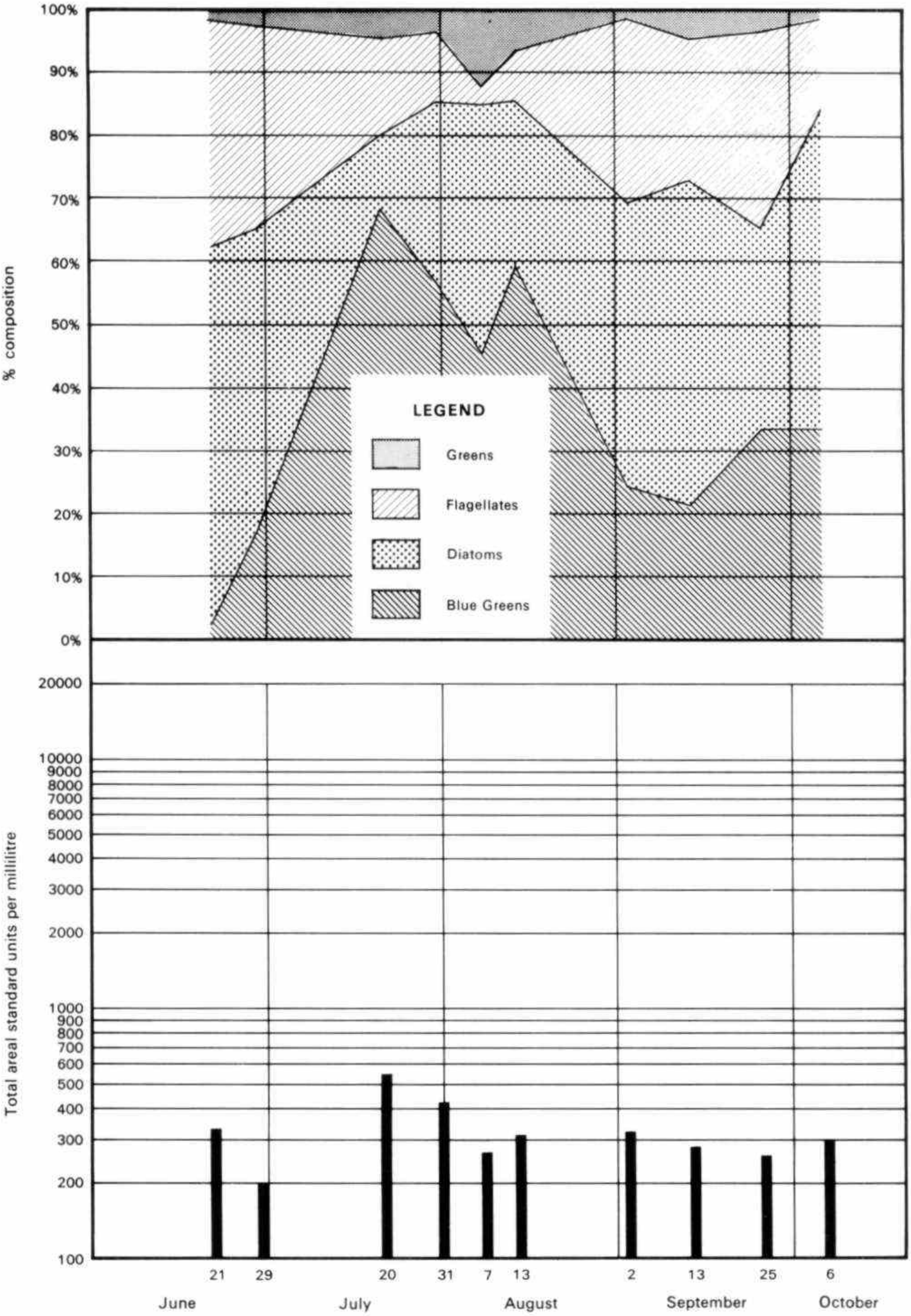


Figure 9. Phytoplankton stocks and composition in the euphotic zone of Attawapiskat Lake during the ice-free period of 1970.

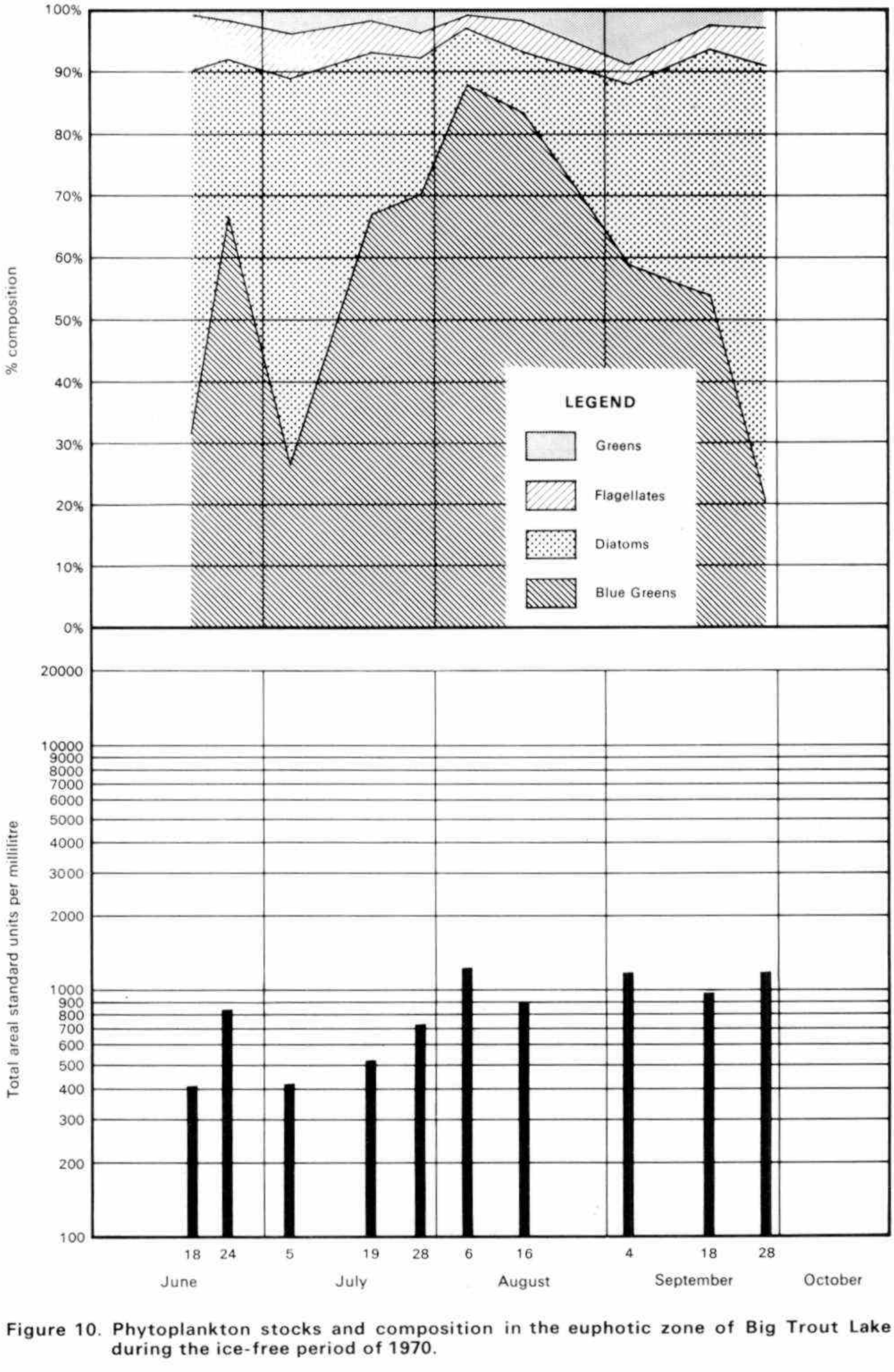


Figure 10. Phytoplankton stocks and composition in the euphotic zone of Big Trout Lake during the ice-free period of 1970.

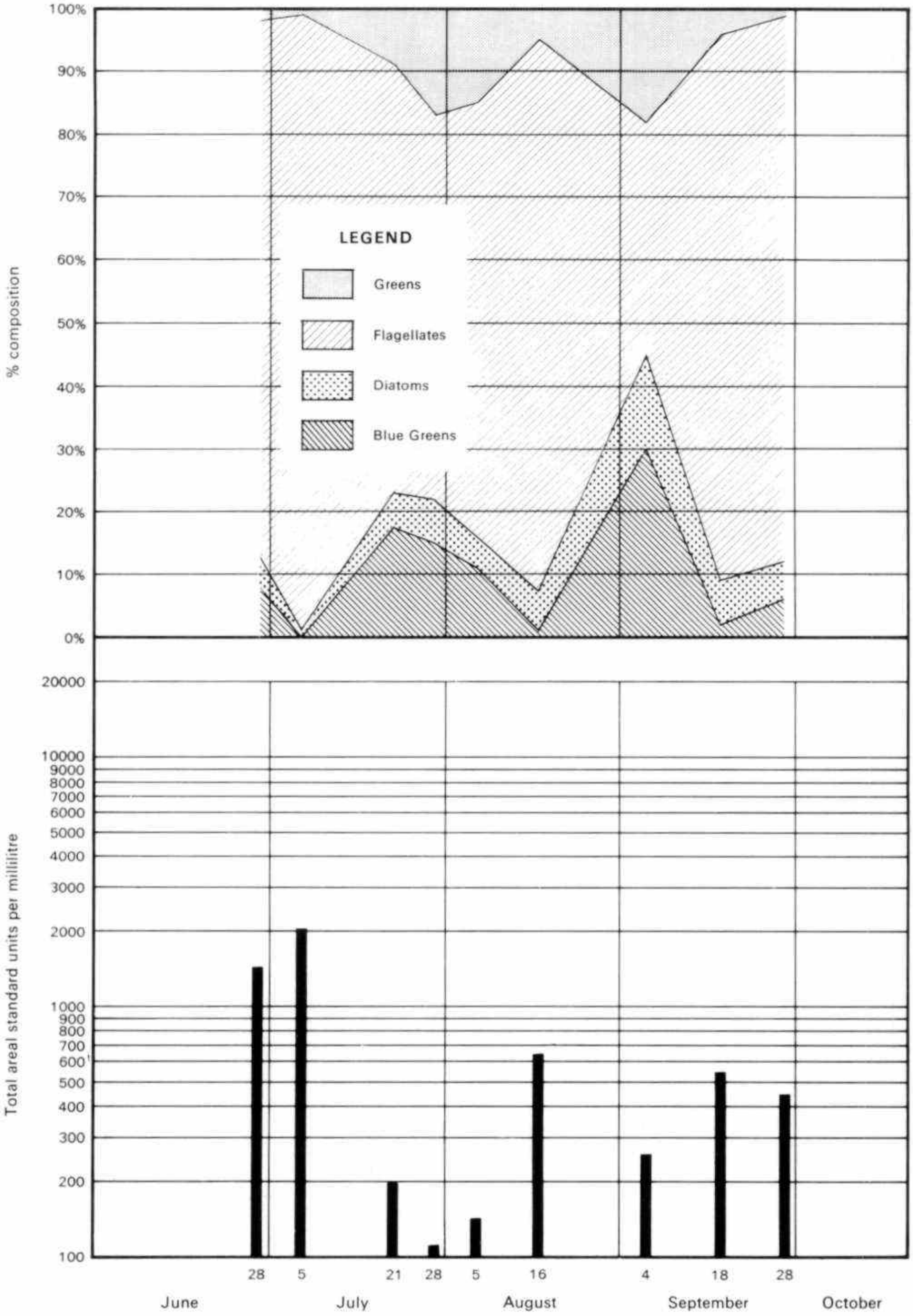


Figure 11. Phytoplankton stocks and composition in the euphotic zone of Big Trout Lake Bog during the ice-free period of 1970.

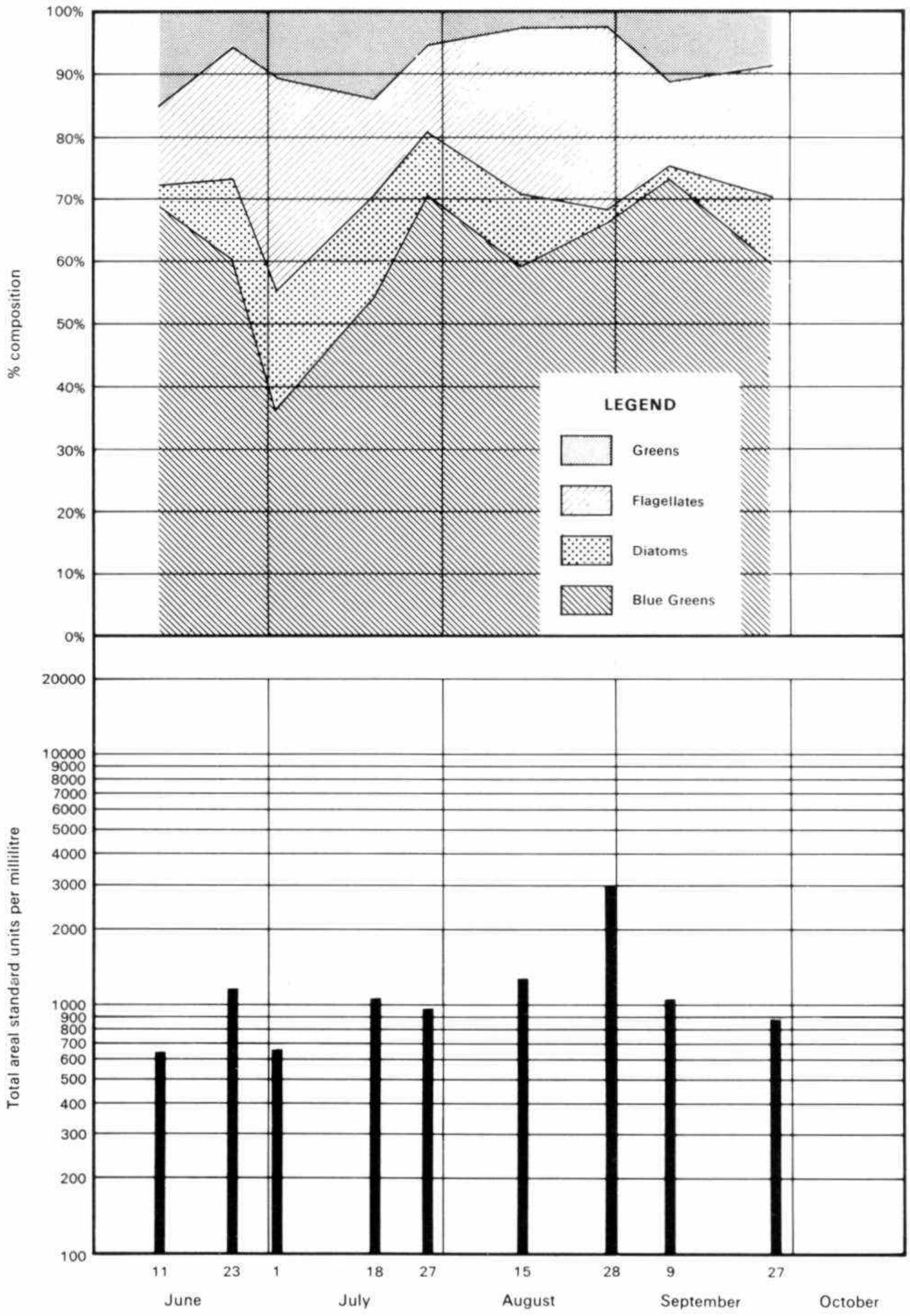


Figure 12. Phytoplankton stocks and composition in the euphotic zone of Blue Goose Lake during the ice-free period of 1971.

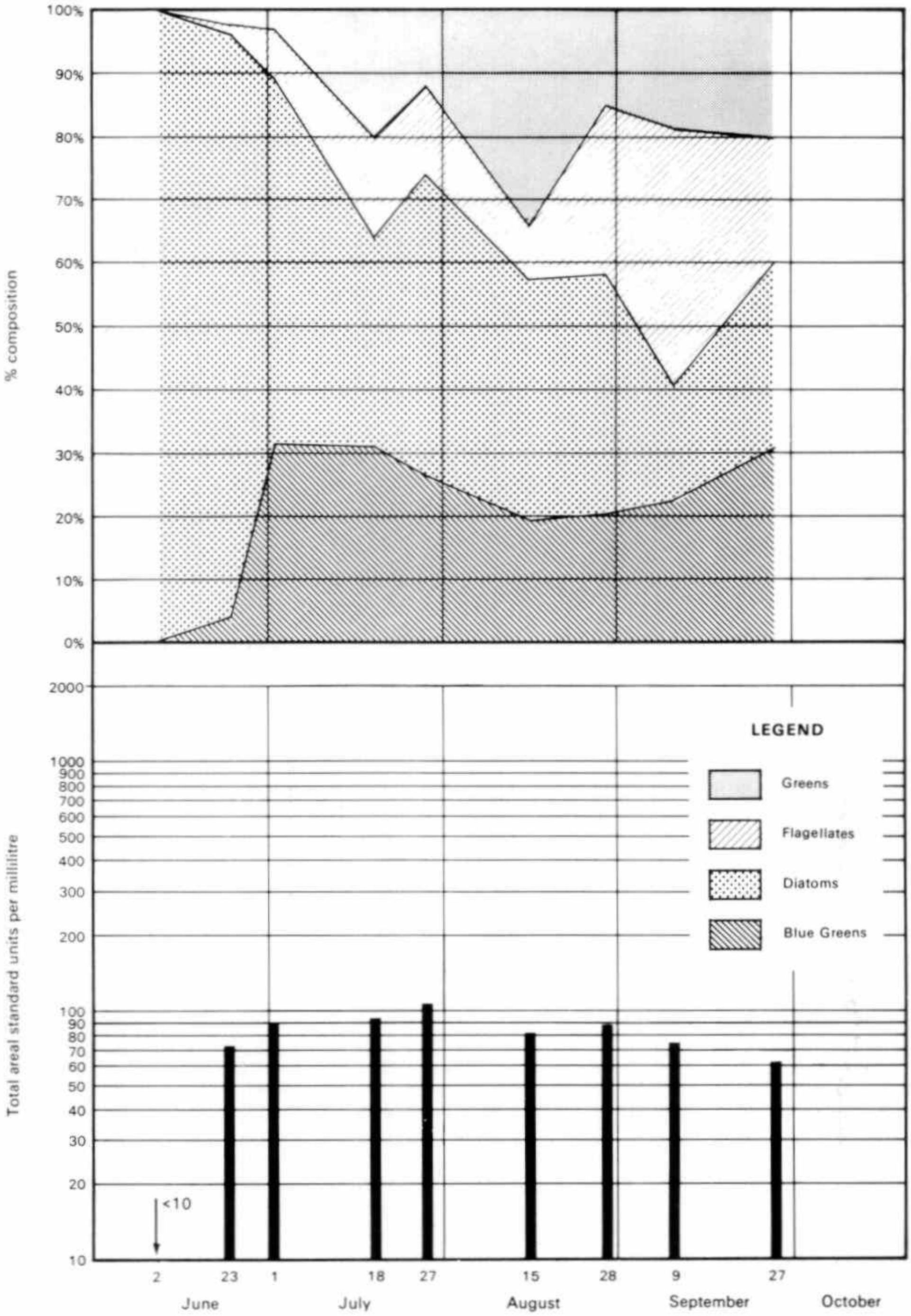


Figure 13. Phytoplankton stocks and composition in the euphotic zone of Bluejay Lake during the ice-free period of 1971.

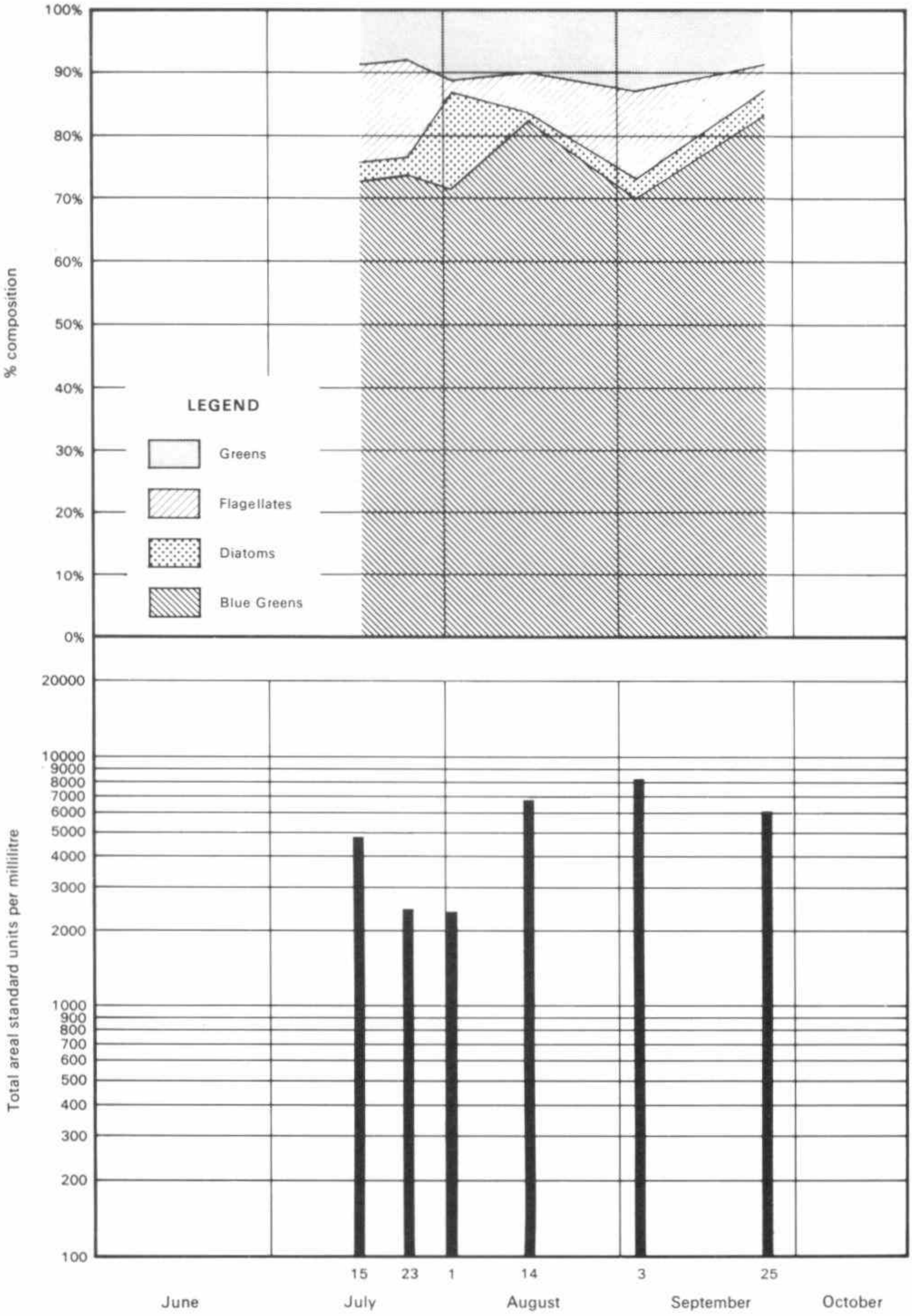


Figure 14. Phytoplankton stocks and composition in the euphotic zone of Bog Lake during the ice-free period of 1971.

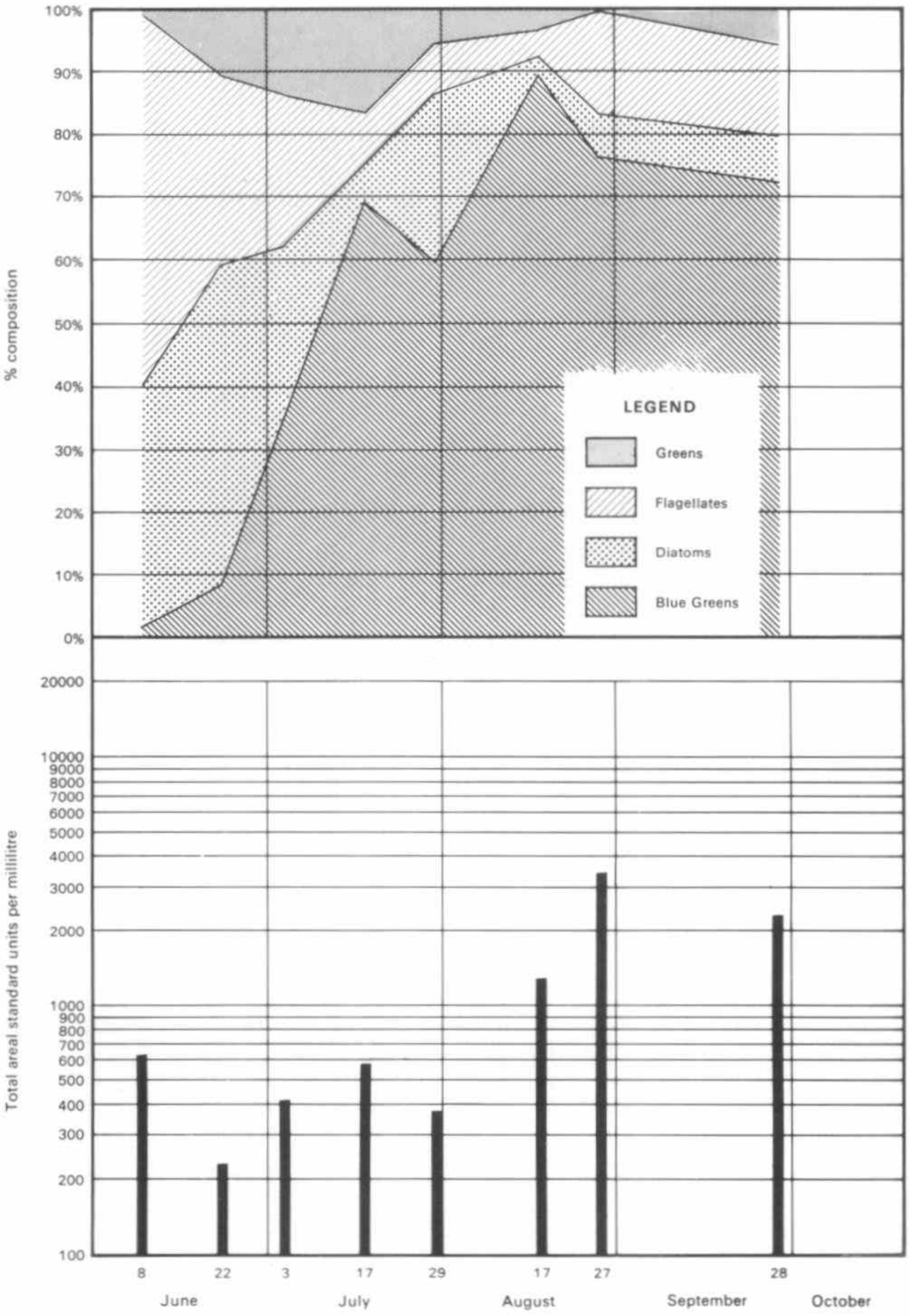


Figure 15. Phytoplankton stocks and composition in the euphotic zone of Brunswick Lake during the ice-free period of 1971.

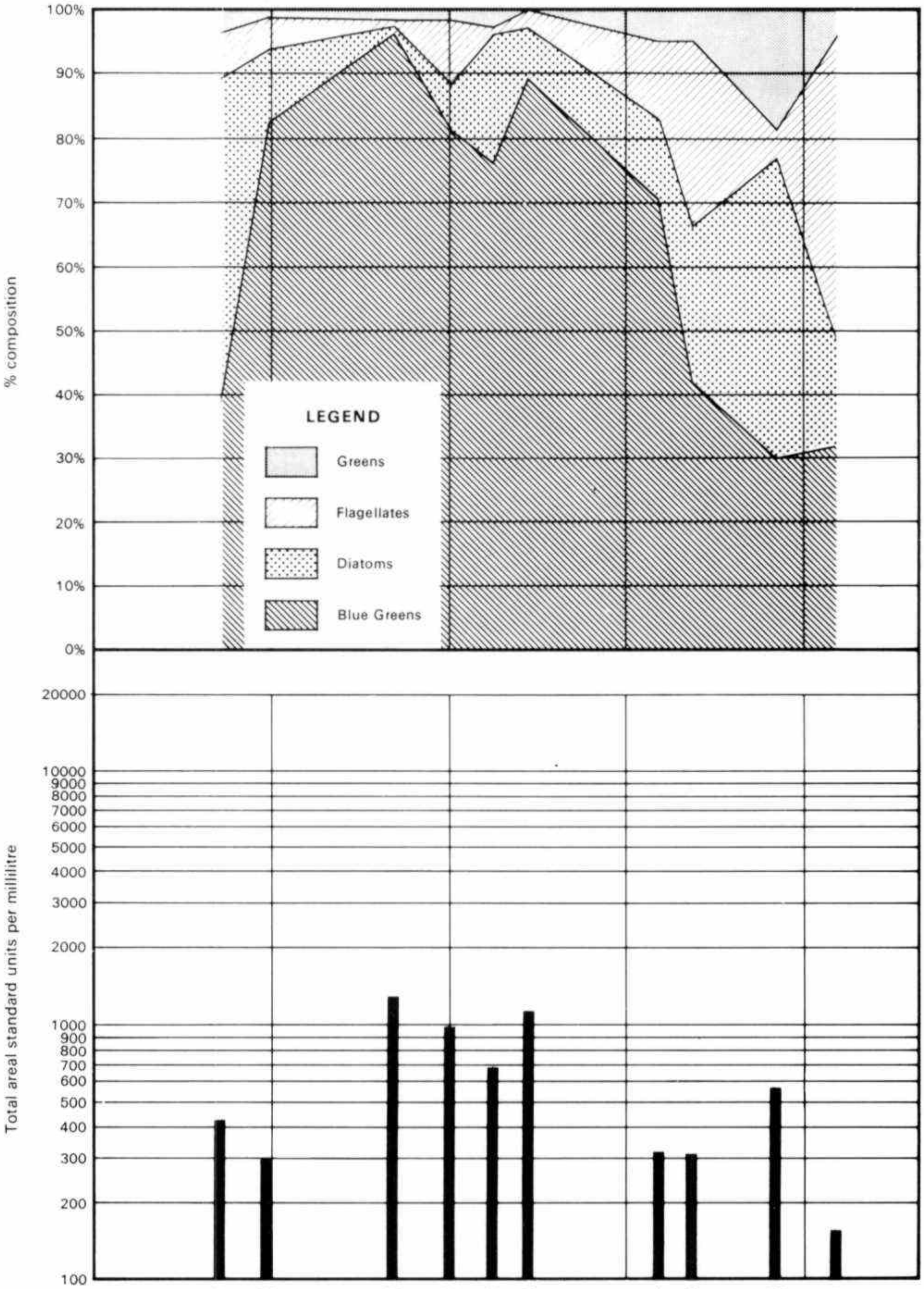


Figure 16. Phytoplankton stocks and composition in the euphotic zone of Kaness Lake during the ice-free period of 1970.

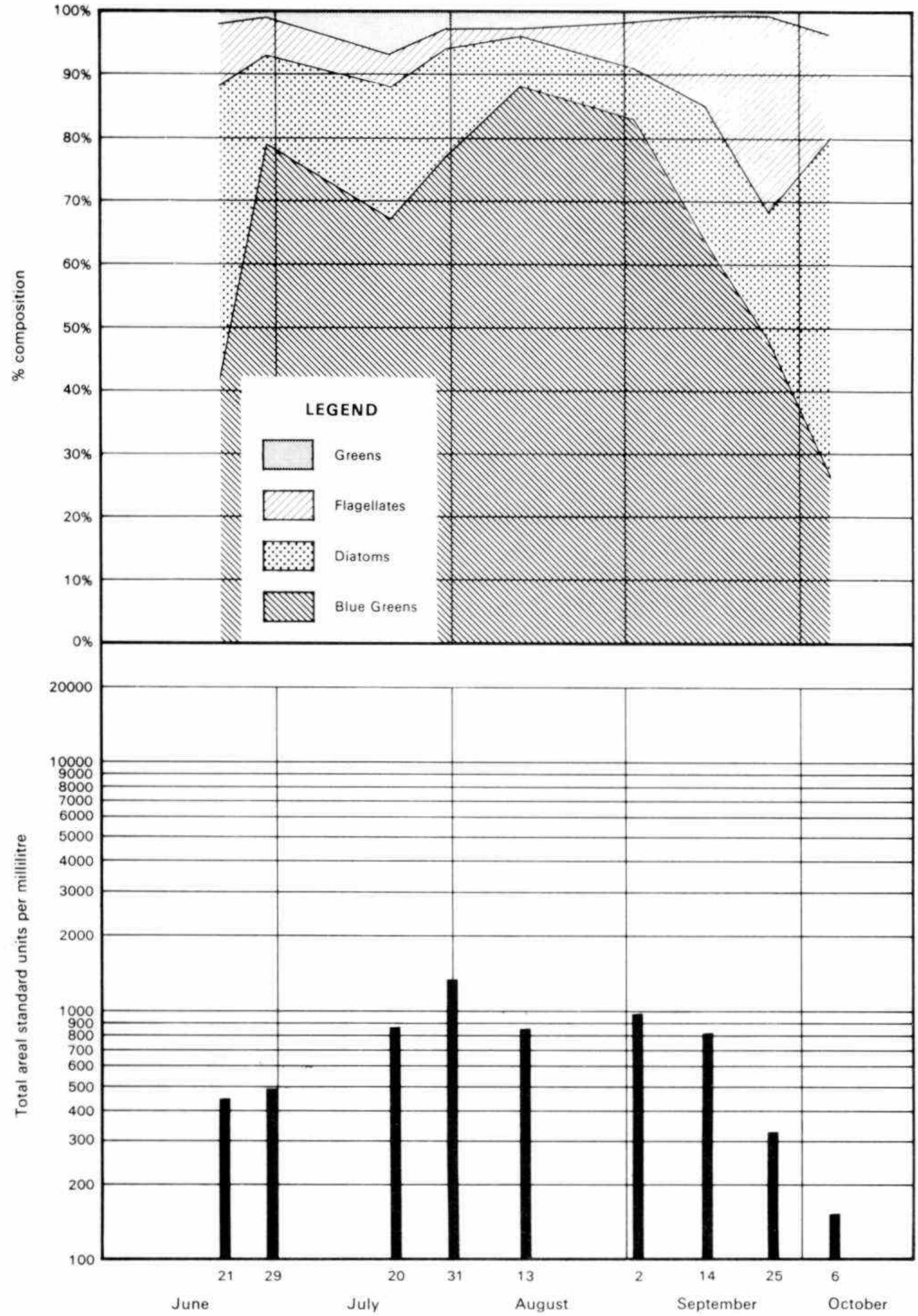


Figure 17. Phytoplankton stocks and composition in the euphotic zone of Kasabonika Lake during the ice-free period of 1970.

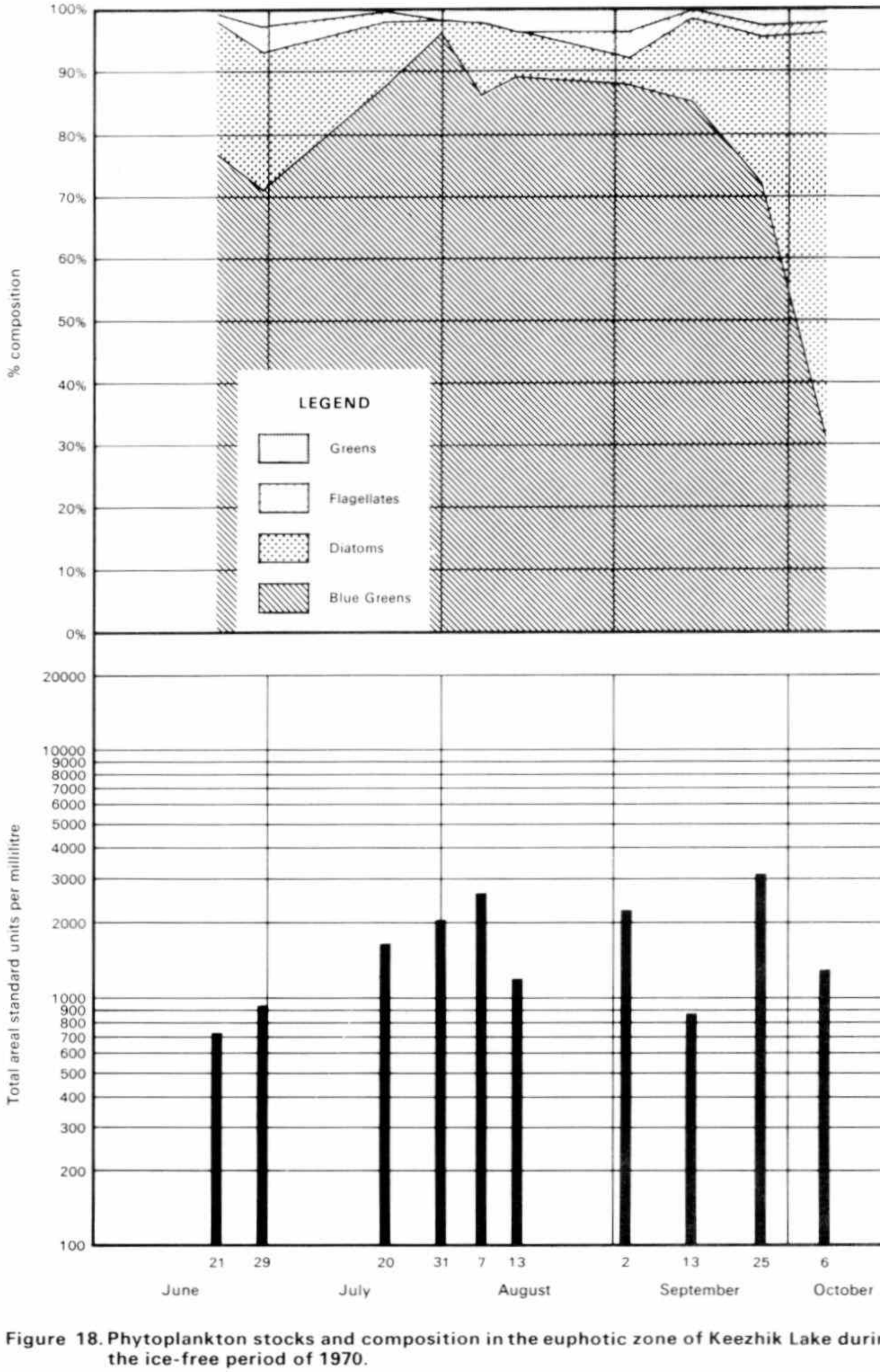


Figure 18. Phytoplankton stocks and composition in the euphotic zone of Keezhik Lake during the ice-free period of 1970.

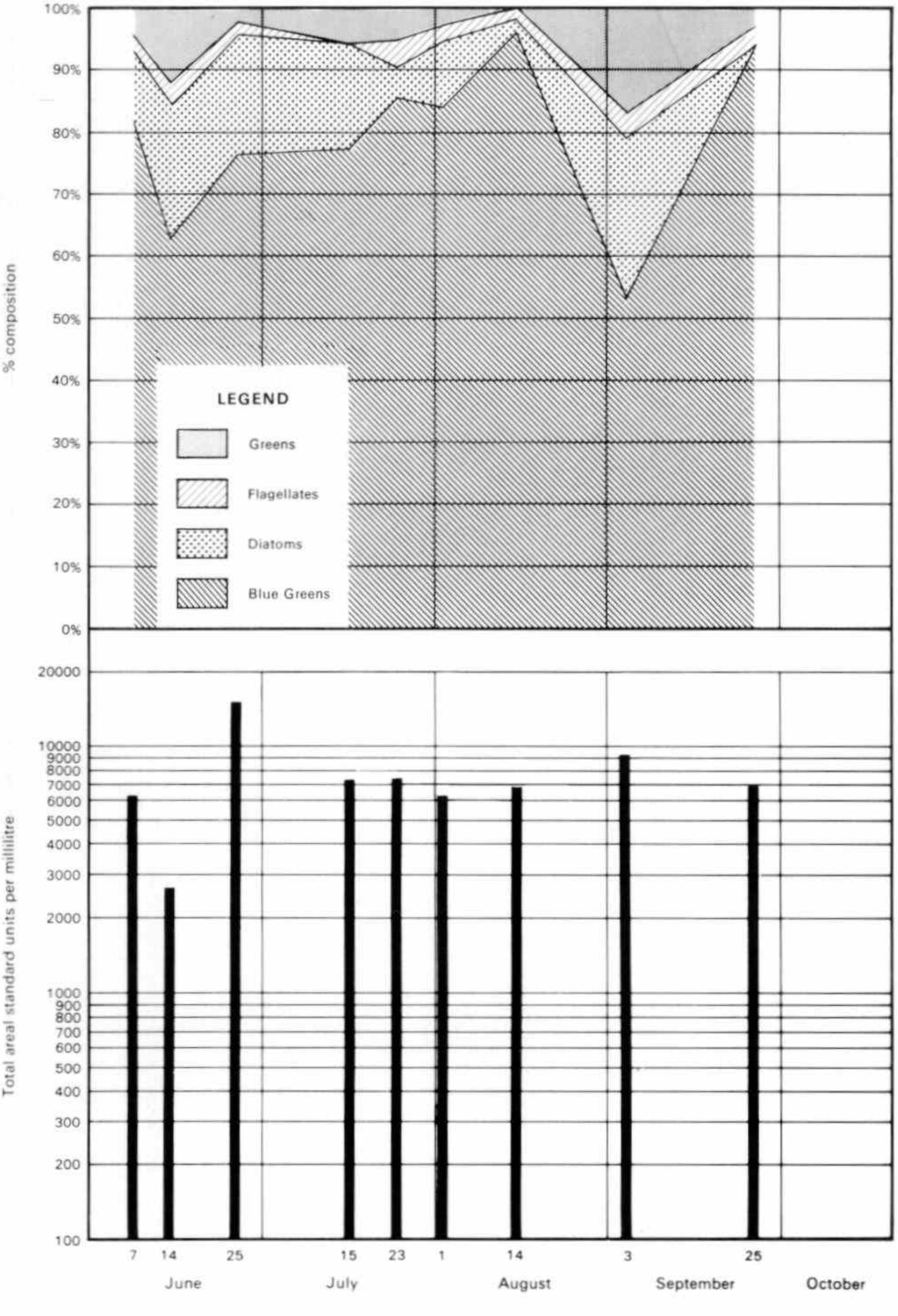


Figure 19. Phytoplankton stocks and composition in the euphotic zone of Lingen Lake during the ice-free period of 1971.

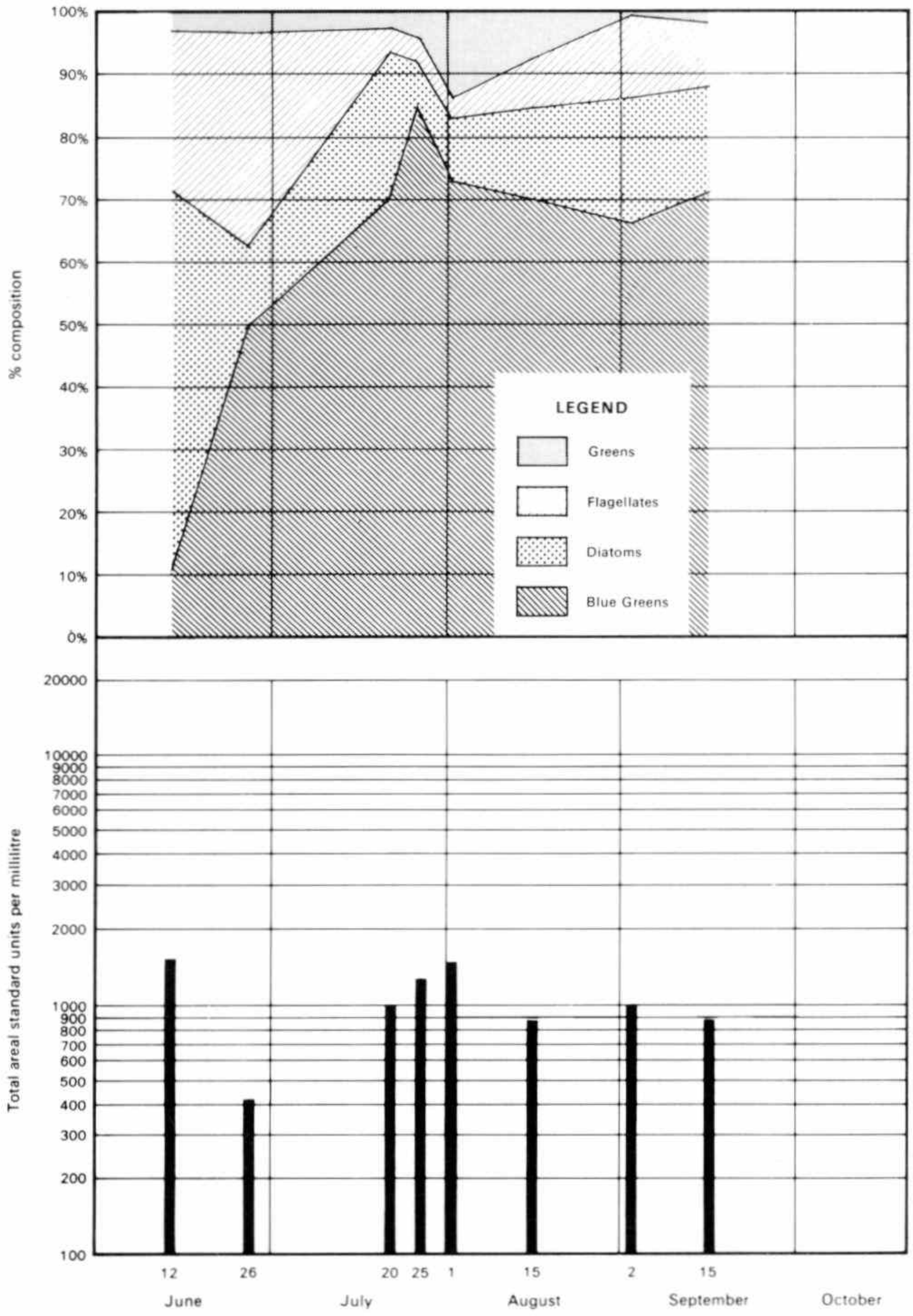


Figure 20. Phytoplankton stocks and composition in the euphotic zone of Lower Twin Lake during the ice-free period of 1971.

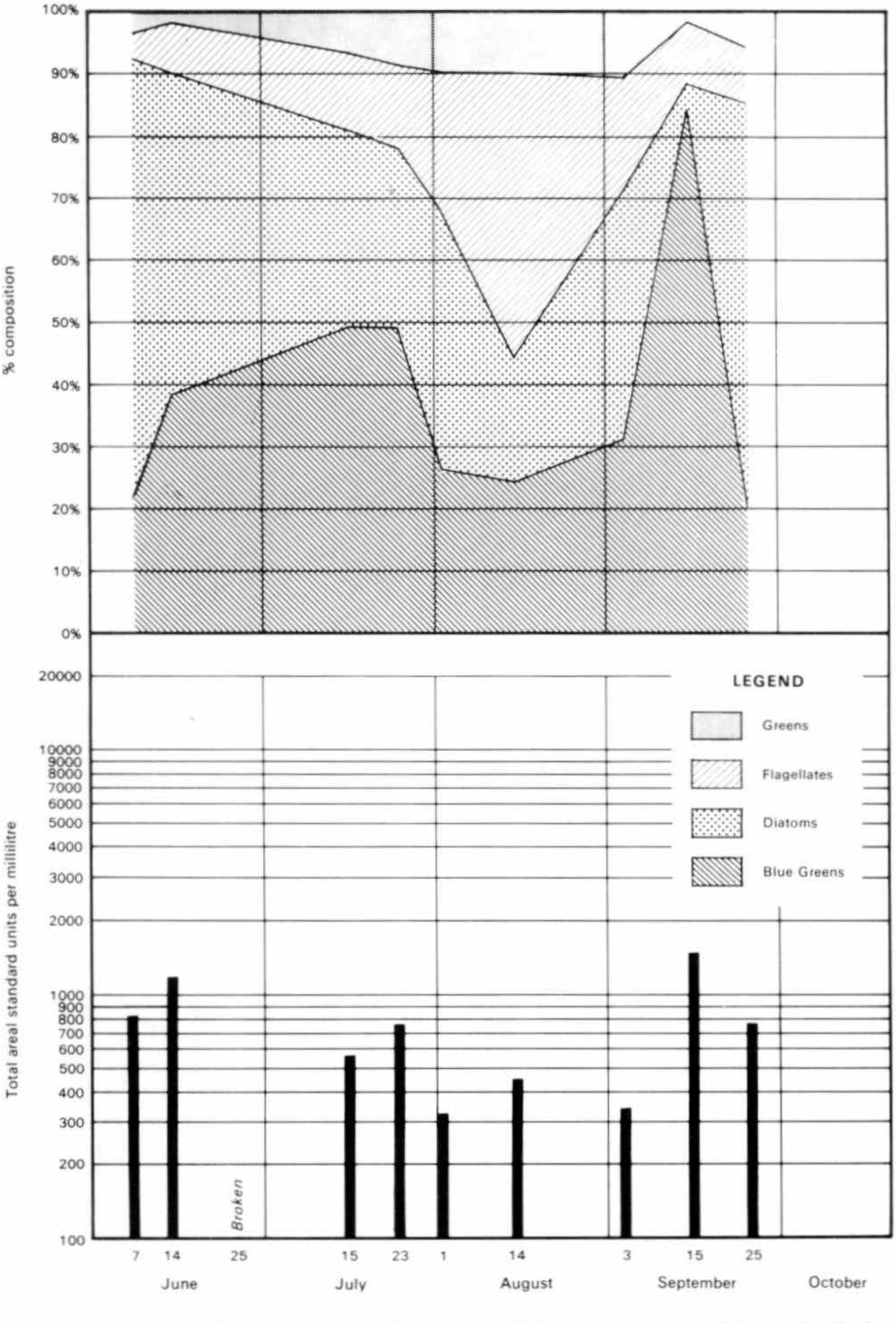


Figure 21. Phytoplankton stocks and composition in the euphotic zone of Lucy Lake during the ice-free period of 1971.

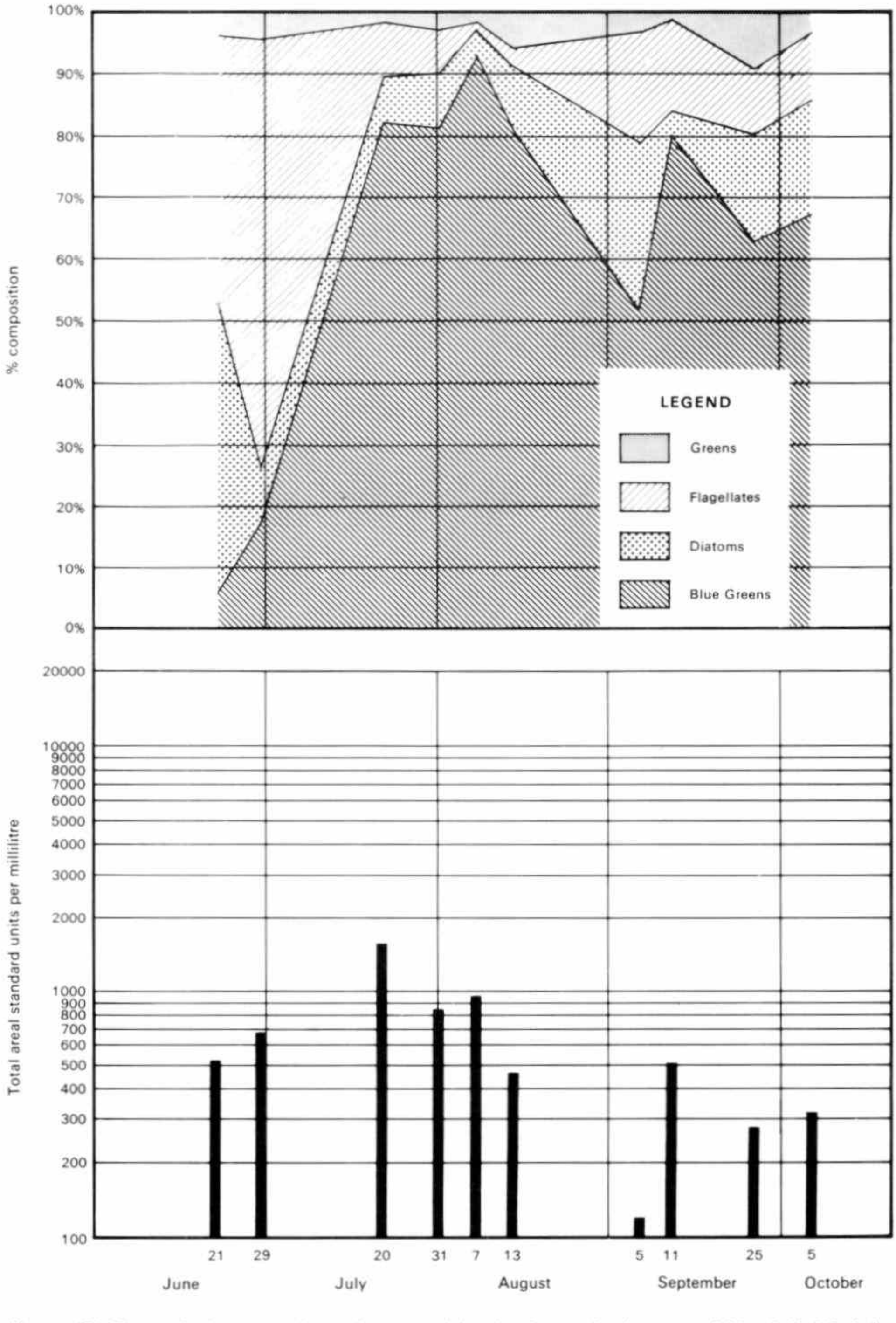


Figure 22. Phytoplankton stocks and composition in the euphotic zone of North Spirit Lake during the ice-free period of 1970.

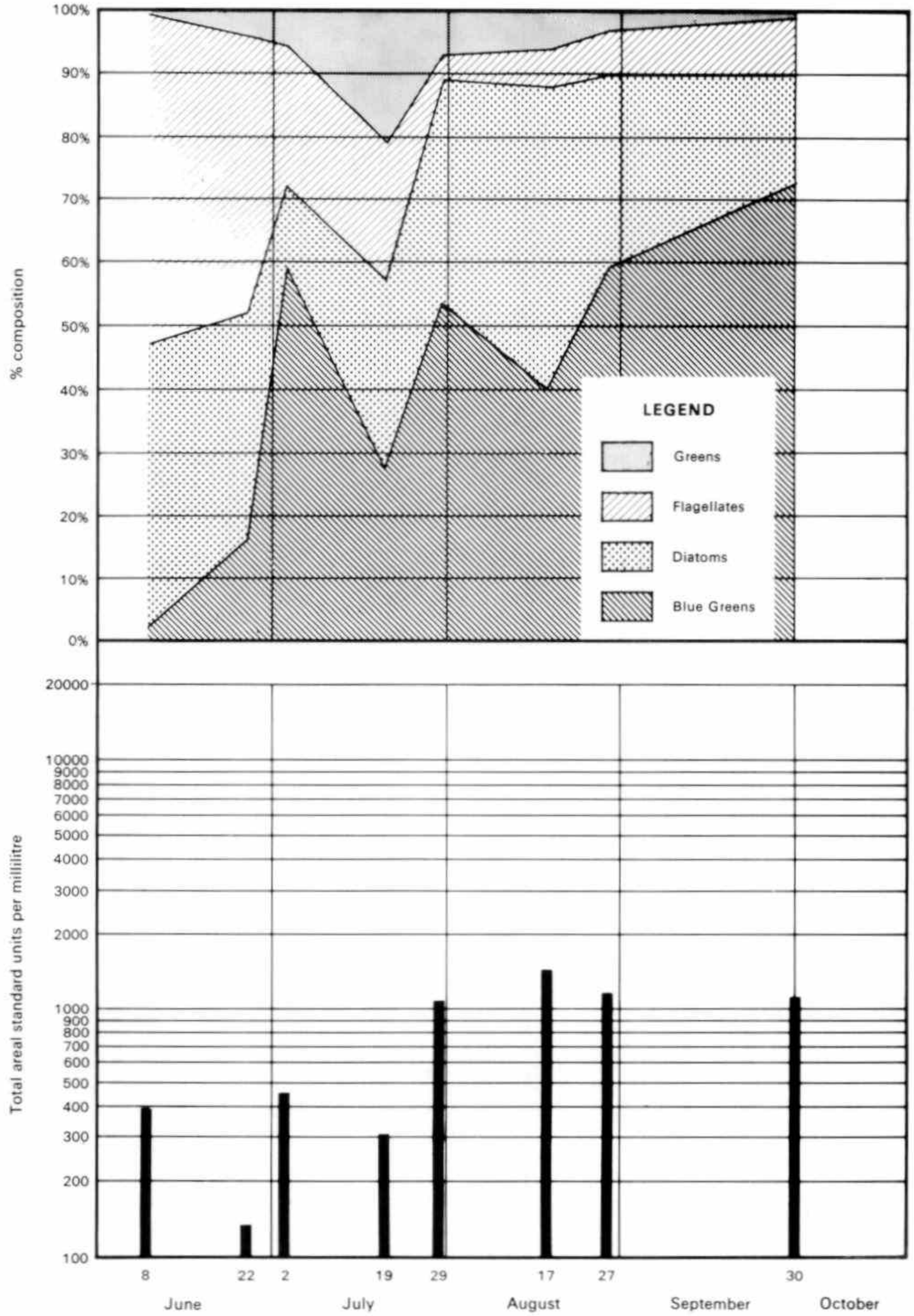


Figure 23. Phytoplankton stocks and composition in the euphotic zone of Pierre Lake during the ice-free period of 1971.

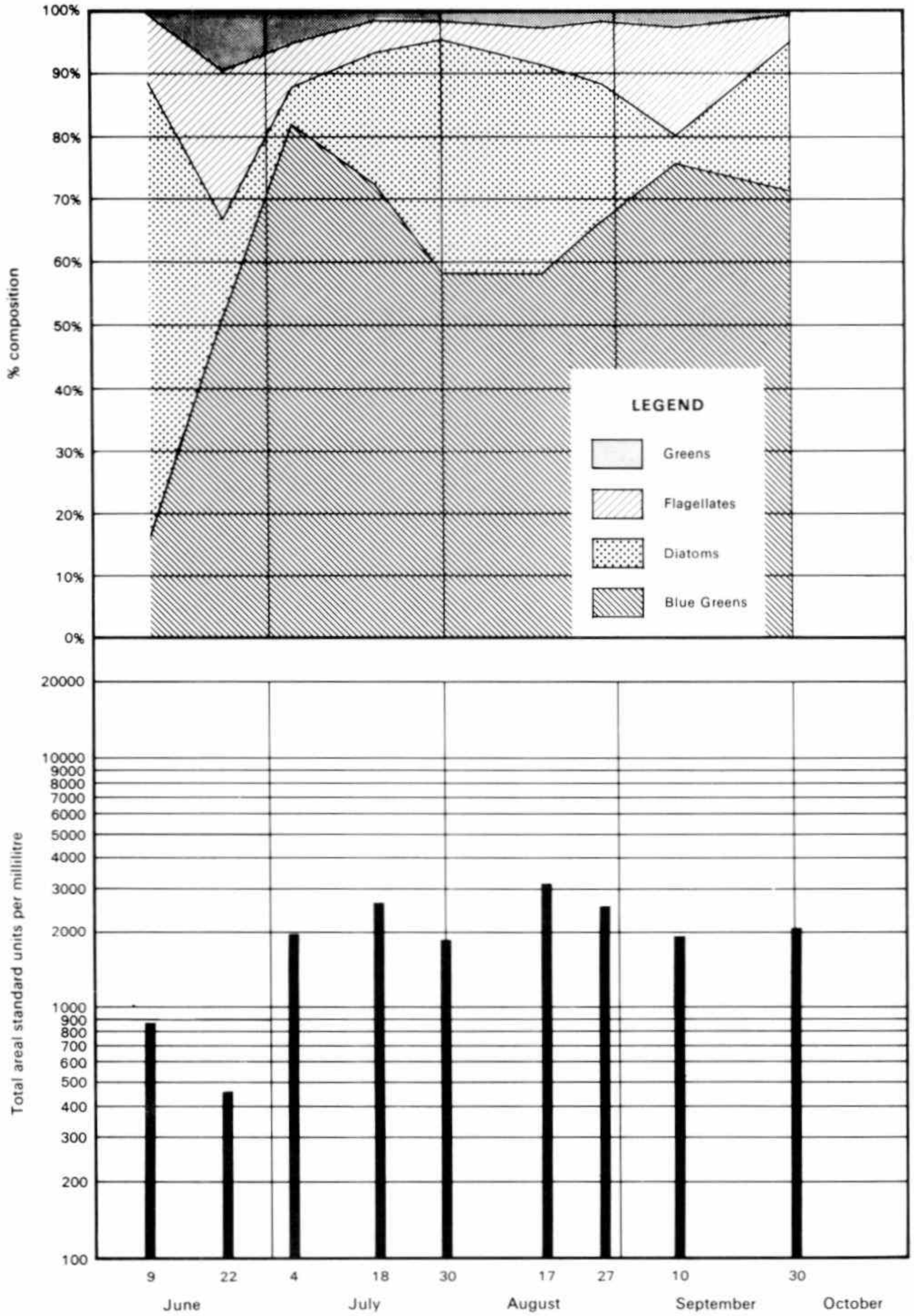


Figure 24. Phytoplankton stocks and composition in the euphotic zone of Remi Lake during the ice-free period of 1971.

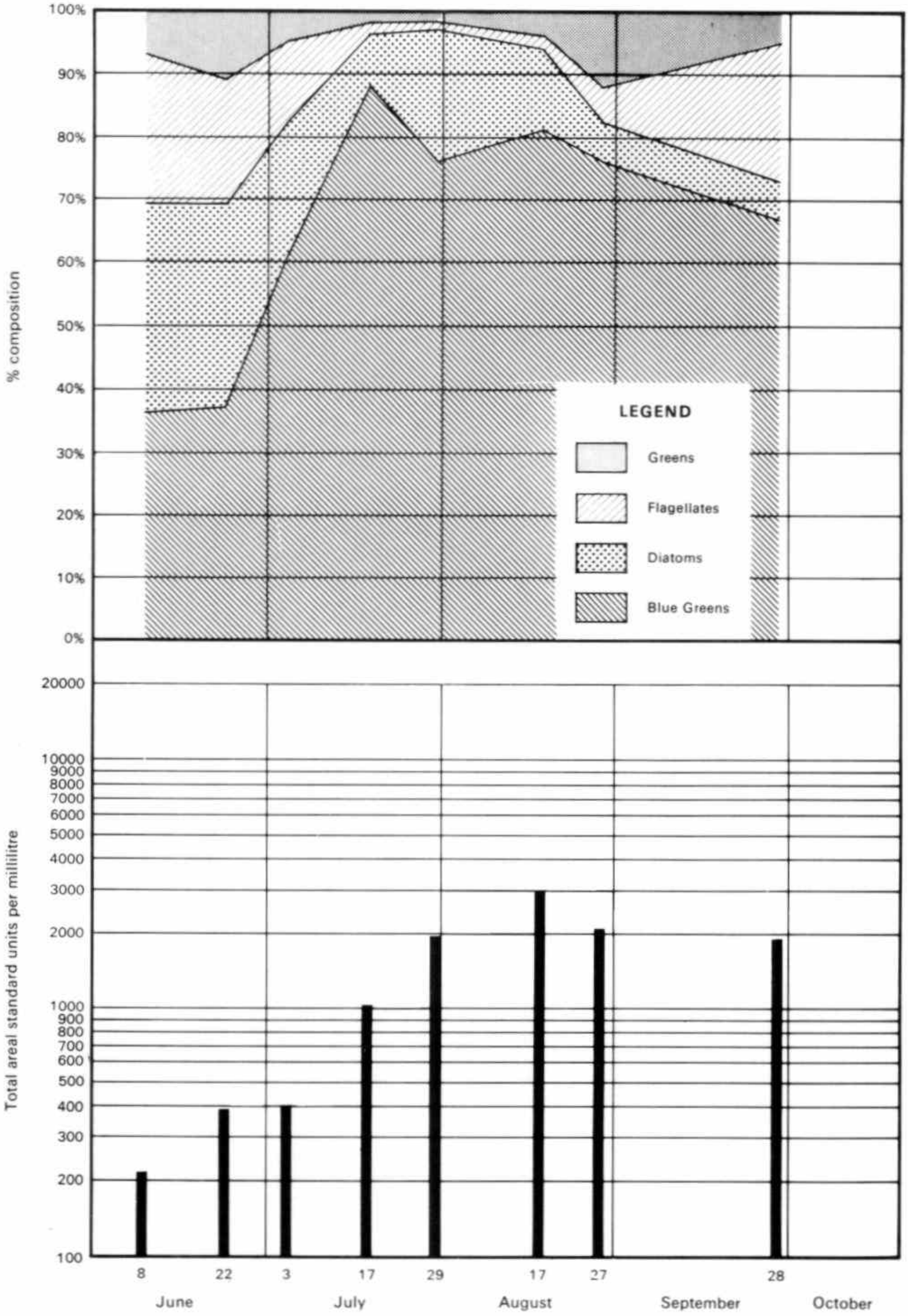


Figure 25. Phytoplankton stocks and composition in the euphotic zone of Saganash Lake during the ice-free period of 1971.

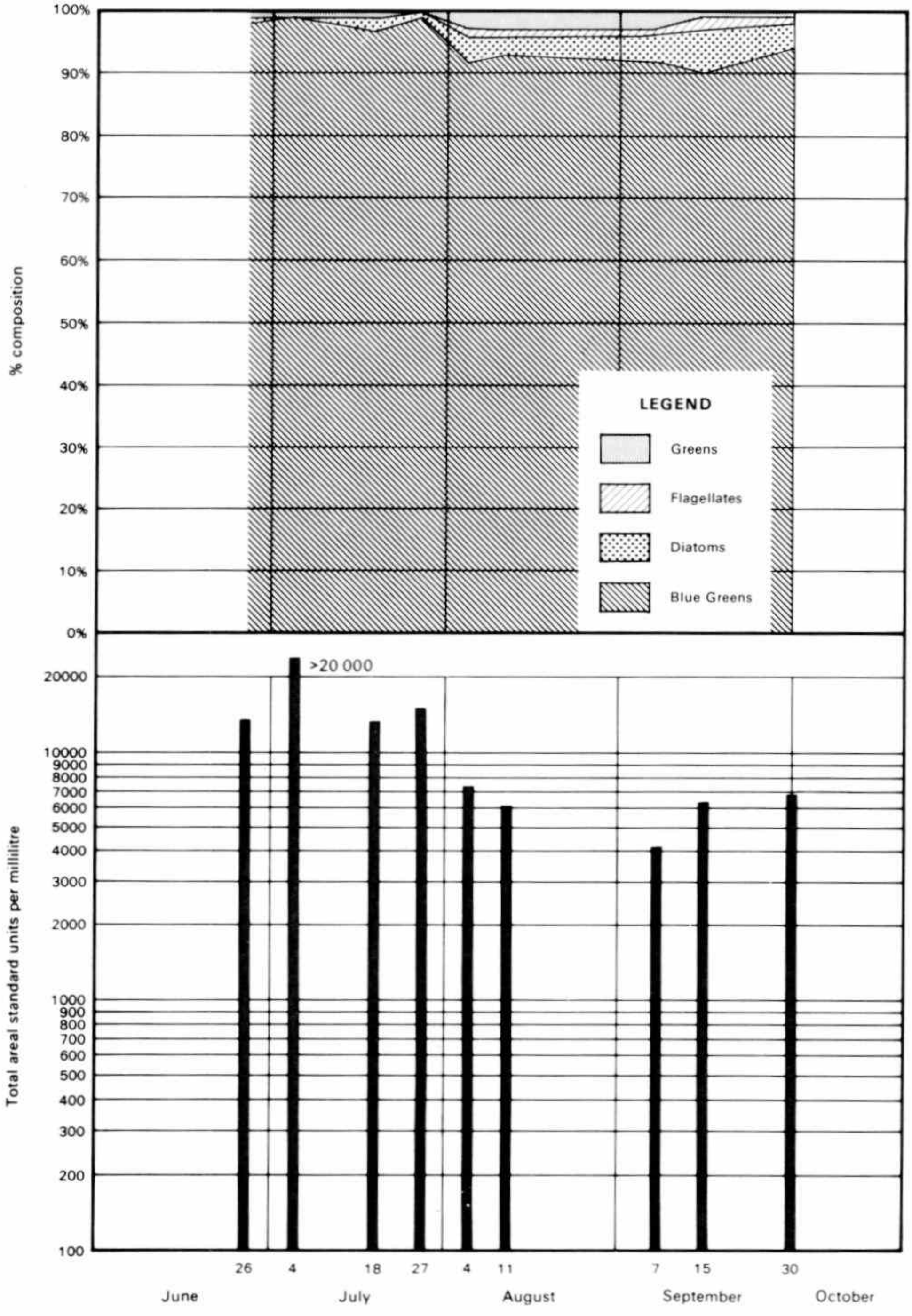


Figure 26. Phytoplankton stocks and composition in the euphotic zone of Sandybank Lake during the ice-free period of 1970.

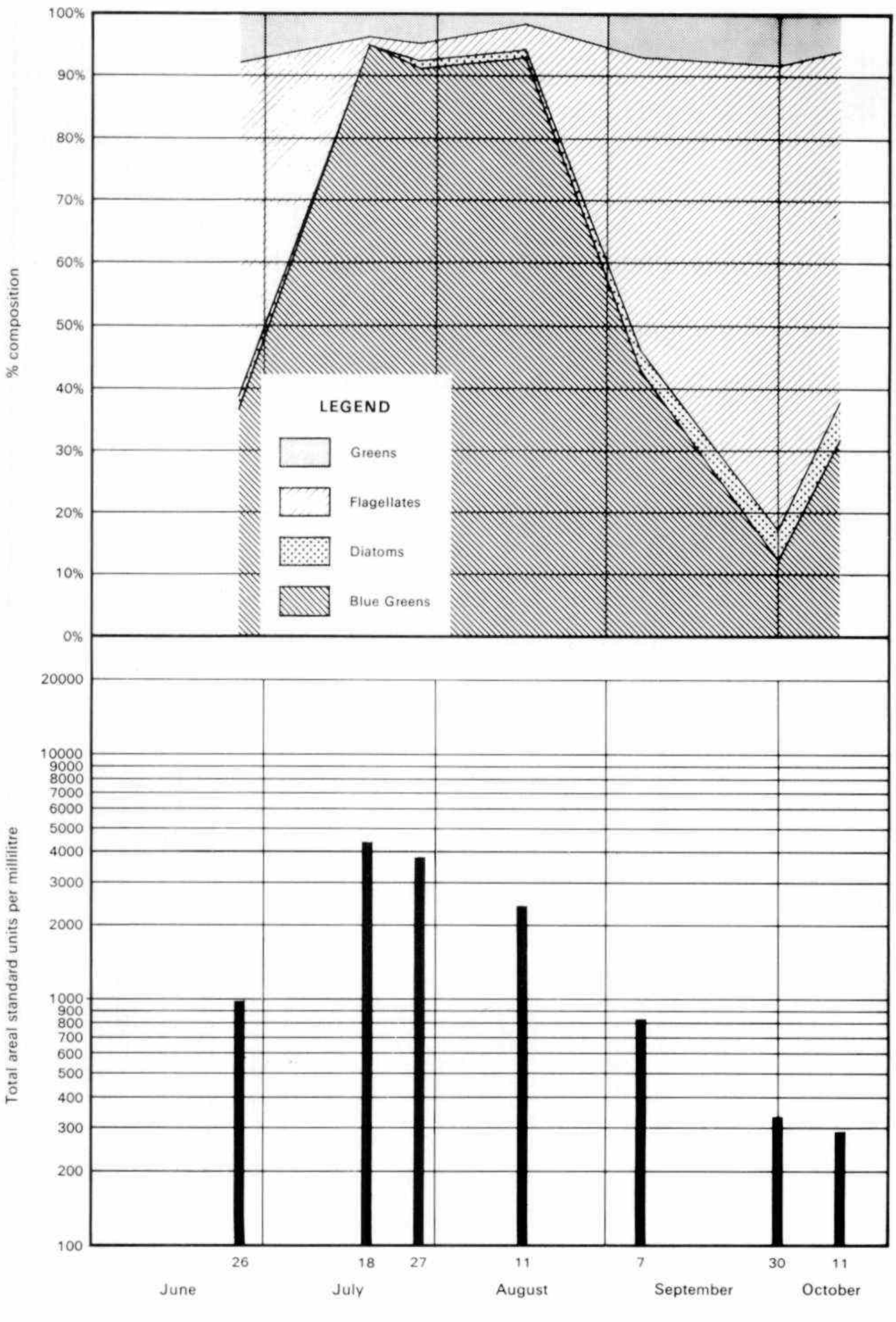


Figure 27. Phytoplankton stocks and composition in the euphotic zone of Shagamu Bog during the ice-free period of 1970.

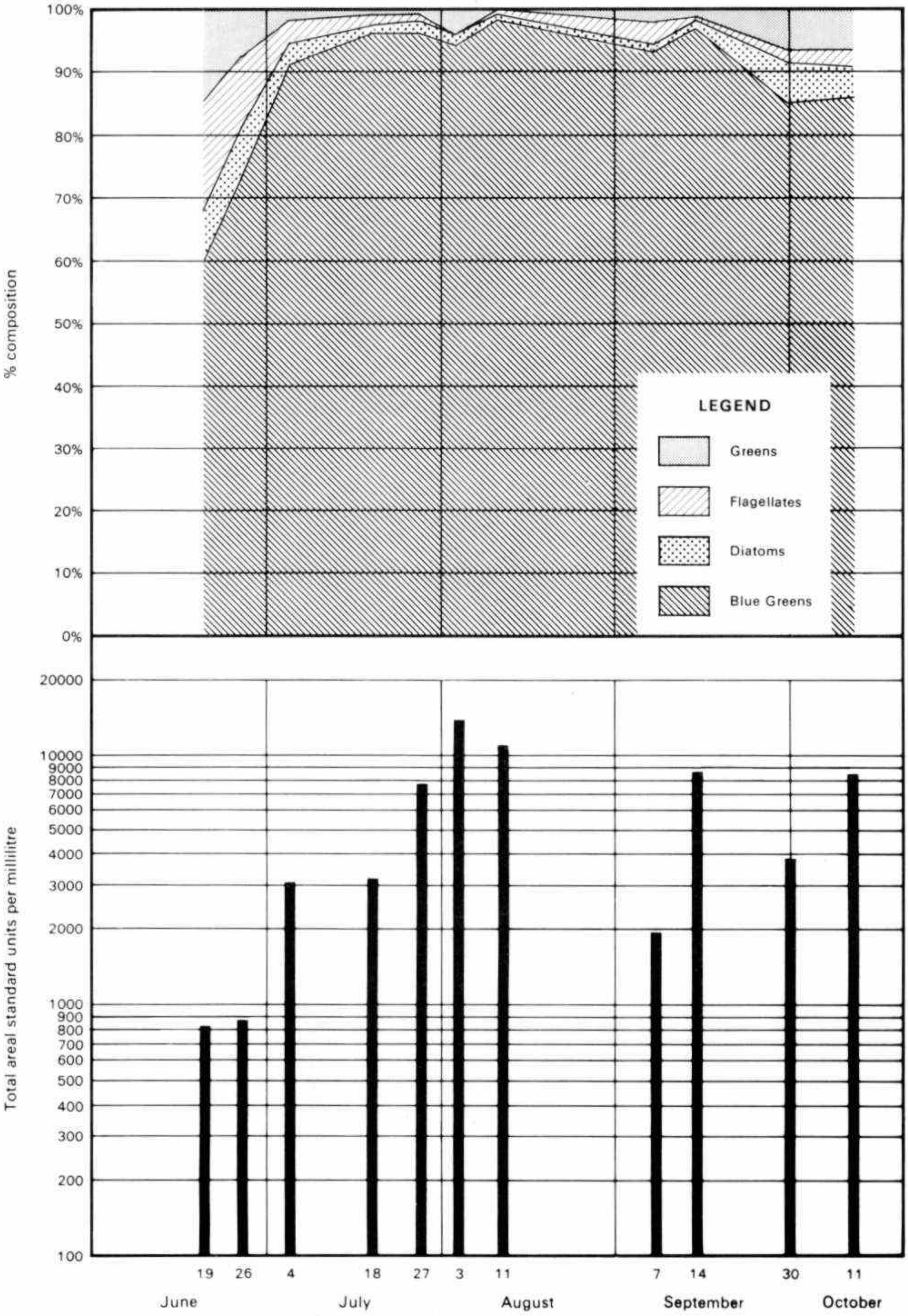


Figure 28. Phytoplankton stocks and composition in the euphotic zone of **Shagamu Lake** during the ice-free period of 1970.

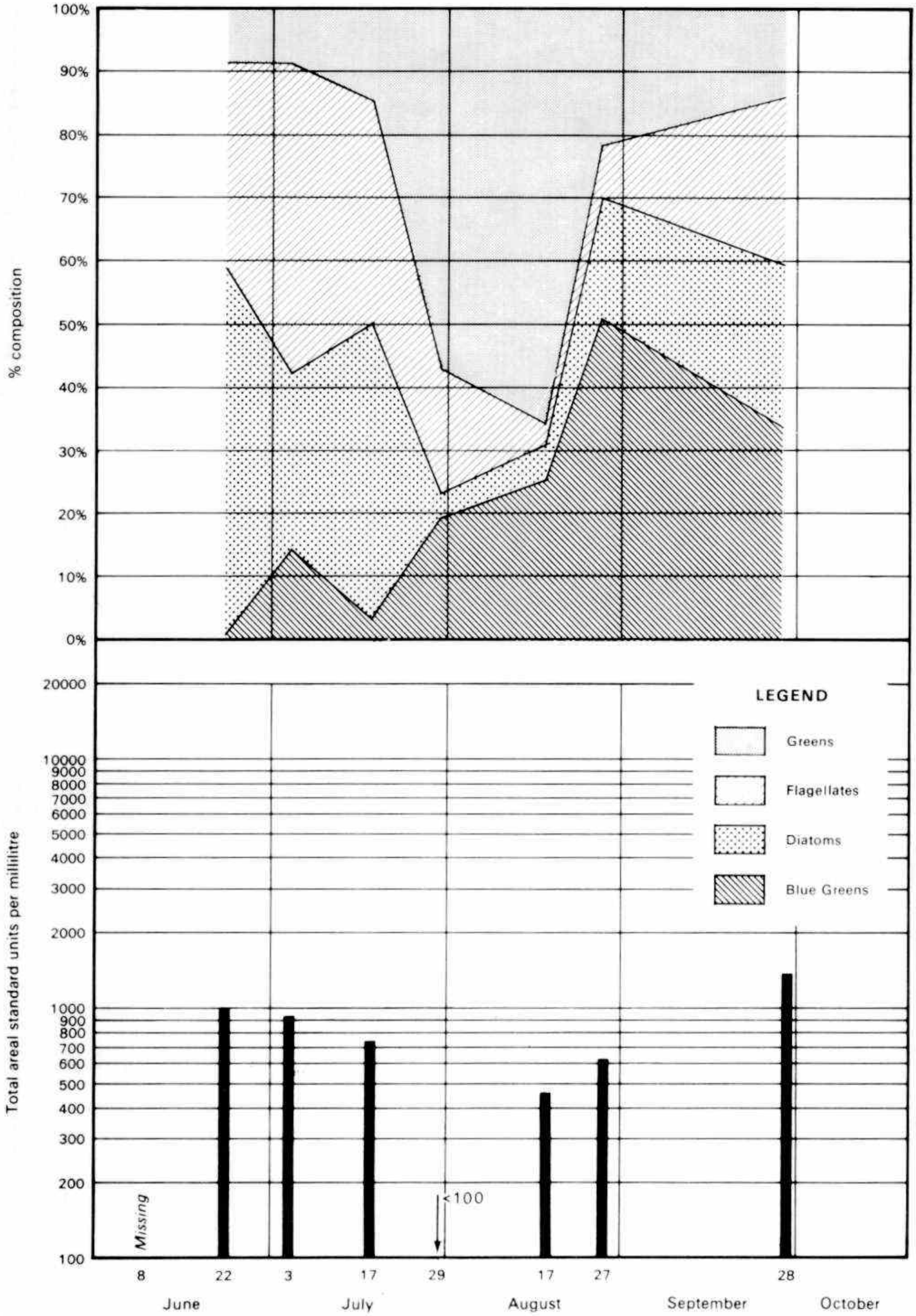


Figure 29. **Phytoplankton stocks and composition in the euphotic zone of Shannon Lake during the ice-free period of 1971.**

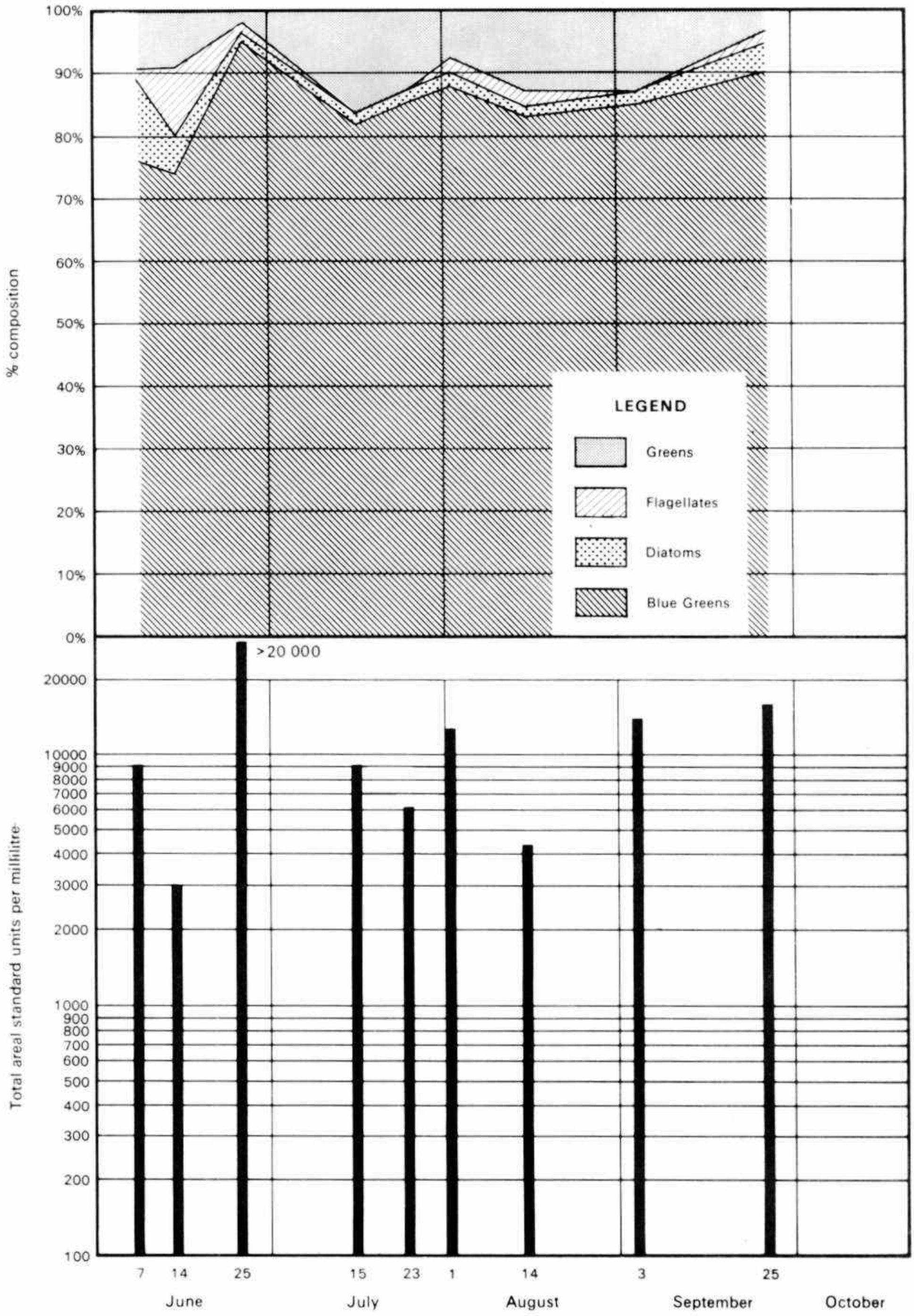


Figure 30. **Phytoplankton stocks and composition in the euphotic zone of Streatfield Lake during the ice-free period of 1971.**

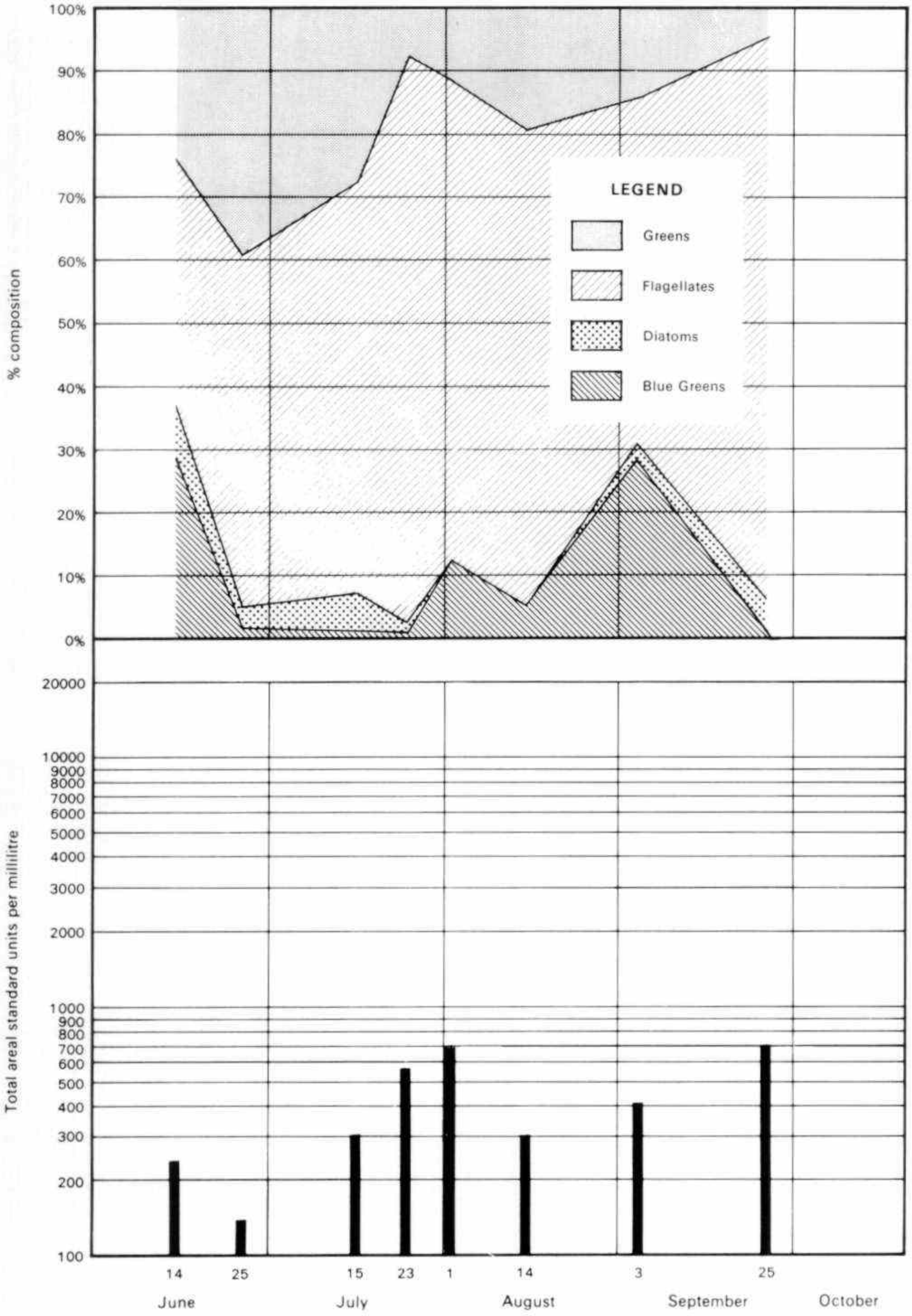


Figure 31. **Phytoplankton stocks and composition in the euphotic zone of String Bog during the ice-free period of 1971.**

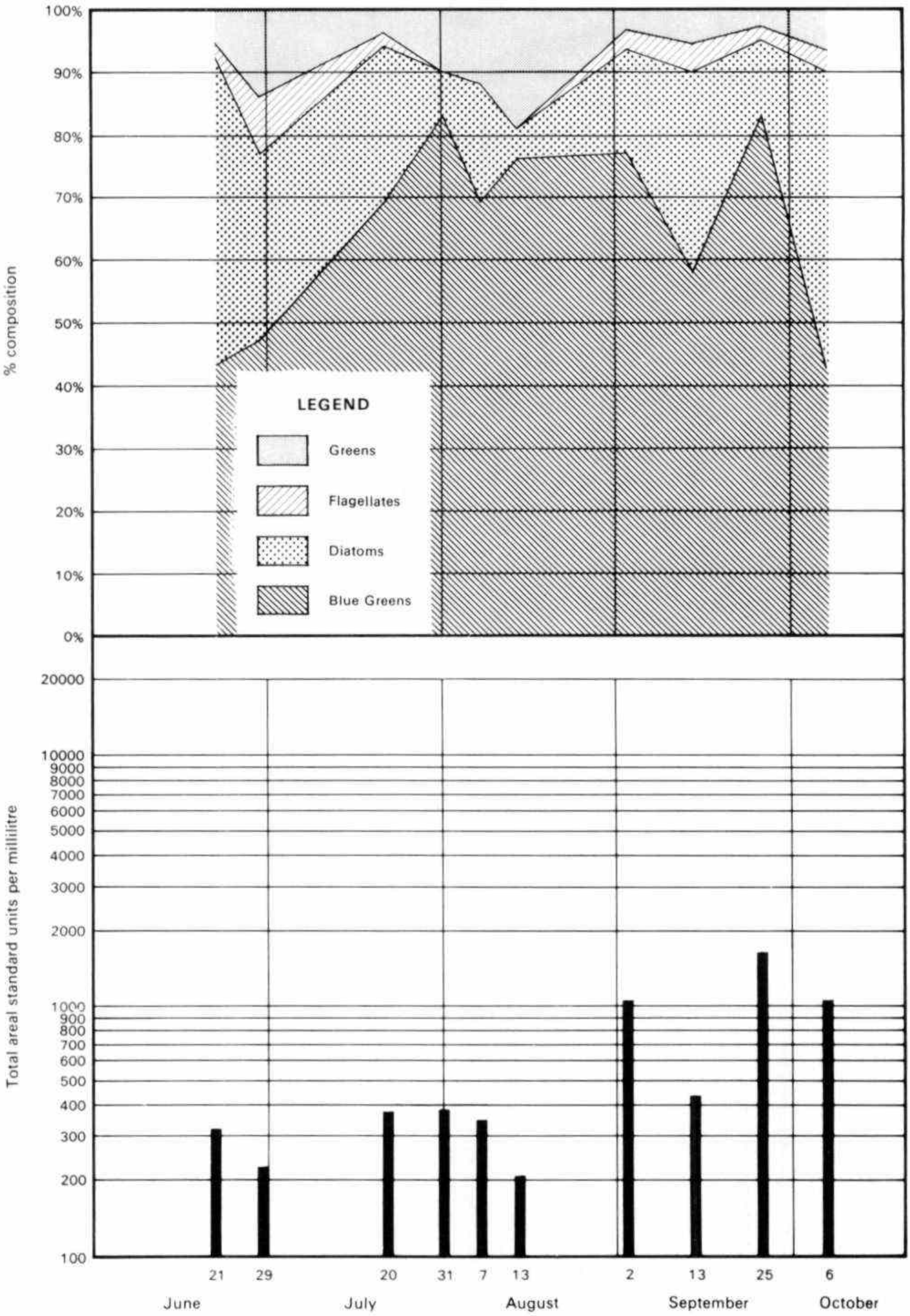


Figure 32. **Phytoplankton stocks and composition in the euphotic zone of Troutfly Lake during the ice-free period of 1970.**

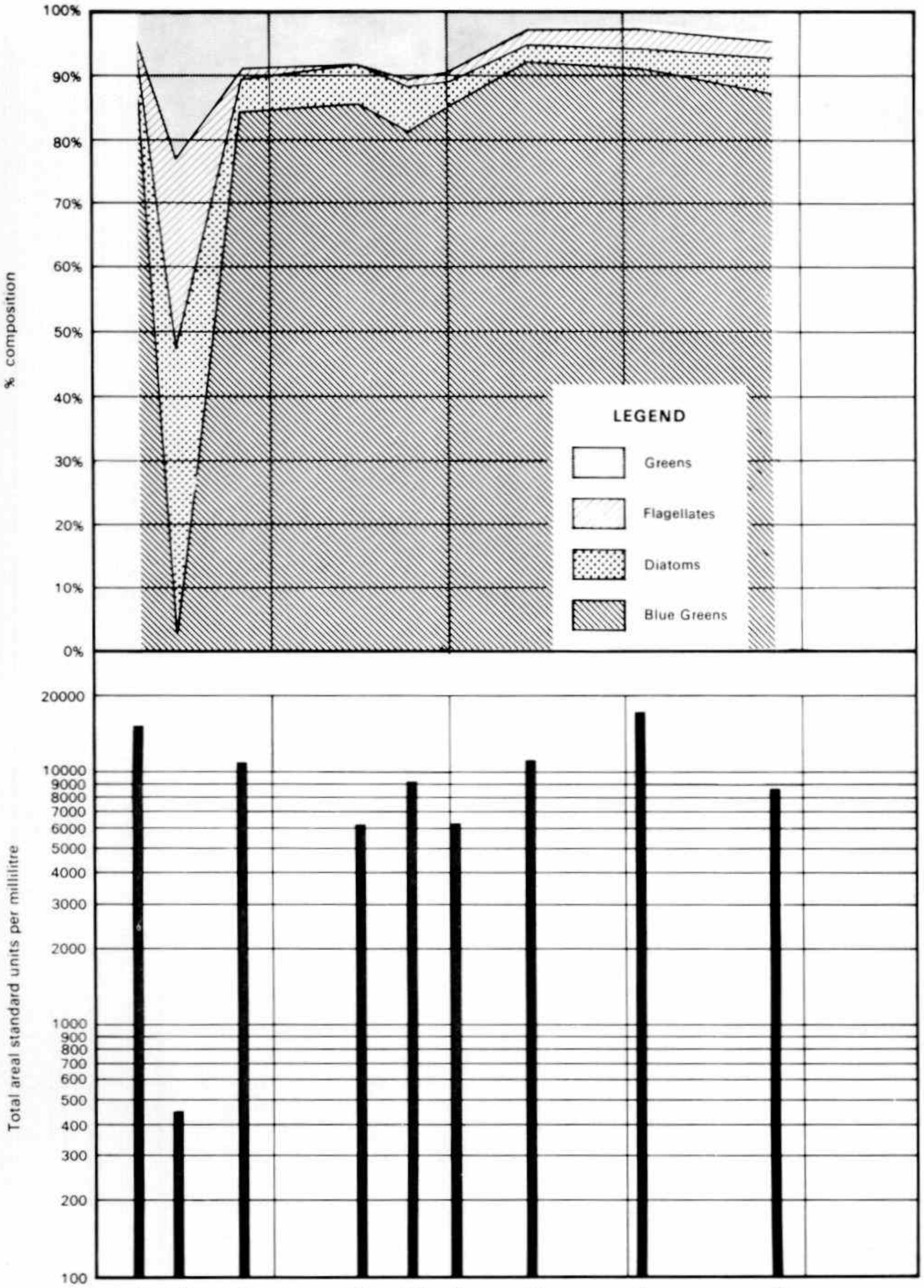


Figure 33. Phytoplankton stocks and composition in the euphotic zone of Wabimeig Lake during the ice-free period of 1971.

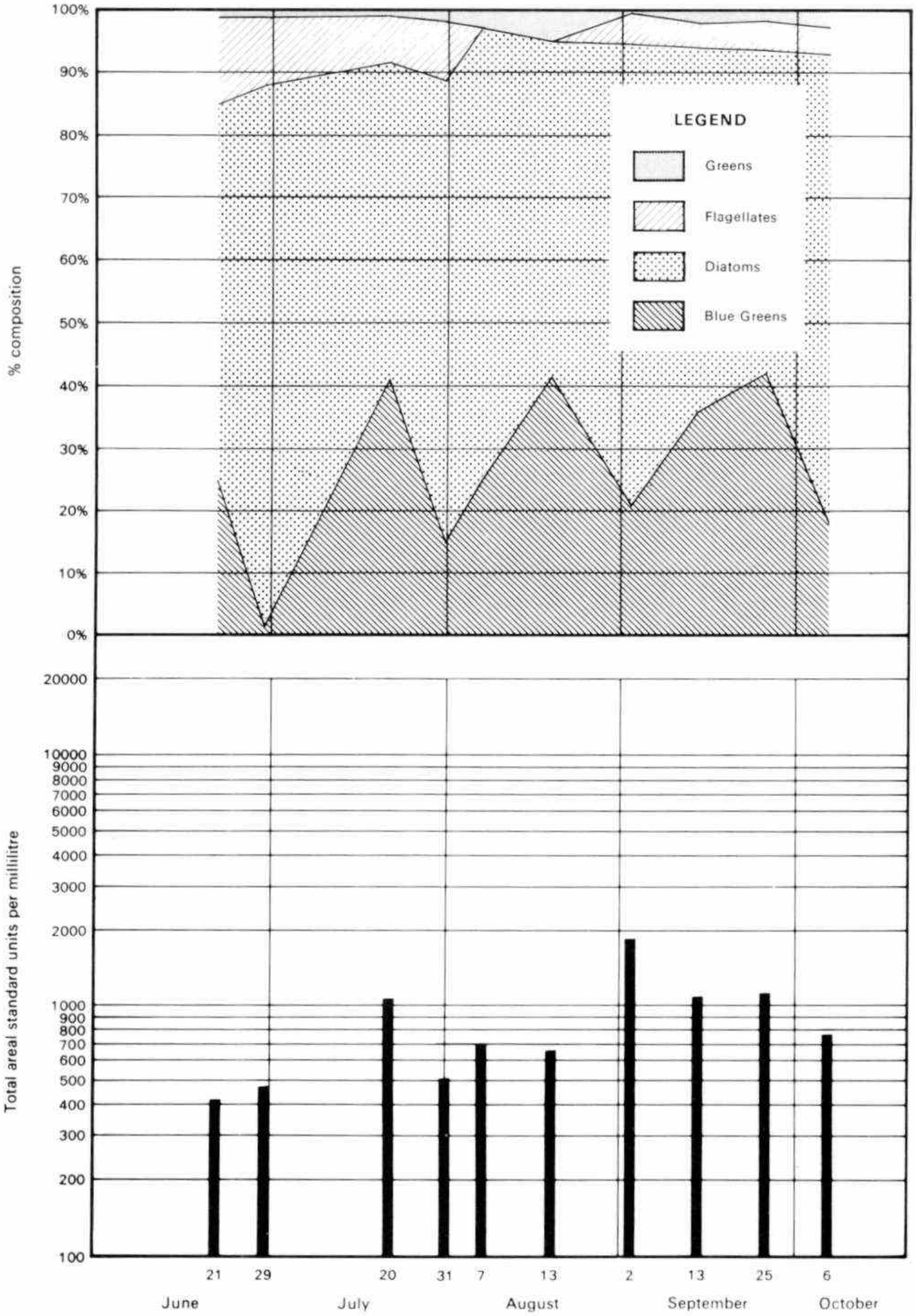
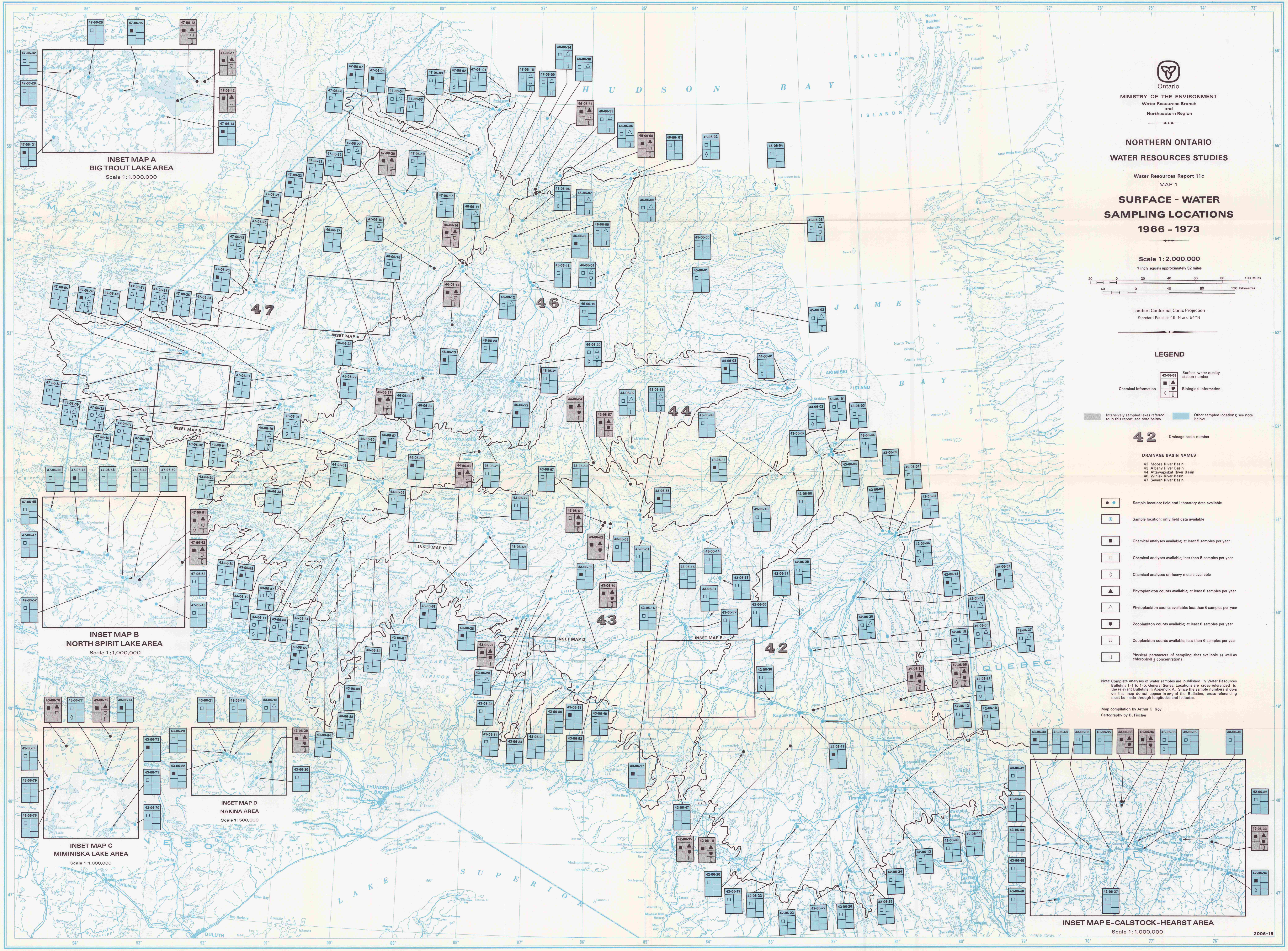


Figure 34. Phytoplankton stocks and composition in the euphotic zone of Wunnummin Lake during the ice-free period of 1970.



Ontario

MINISTRY OF THE ENVIRONMENT
Water Resources Branch
and
Northeastern Region

◆

NORTHERN ONTARIO
WATER RESOURCES STUDIES

Water Resources Report 11c
MAP 1

SURFACE - WATER SAMPLING LOCATIONS 1966 - 1973

◆

Scale 1: 2,000,000
1 inch equals approximately 32 miles

20 0 20 40 60 80 100 Miles
40 0 40 80 120 Kilometres

Lambert Conformal Conic Projection
Standard Parallels 49°N and 54°N

LEGEND

Chemical information	42-06-08	Surface-water quality station number
		Biological information

▨	Intensively sampled lakes referred to in this report, see note below
🟦	Other sampled locations; see note below
42	Drainage basin number

DRAINAGE BASIN NAMES

42 Moose River Basin
43 Albany River Basin
44 Attawapiskat River Basin
46 Winisk River Basin
47 Severn River Basin

● ●	Sample location; field and laboratory data available
⊙	Sample location; only field data available
■	Chemical analyses available; at least 5 samples per year
□	Chemical analyses available; less than 5 samples per year
◊	Chemical analyses on heavy metals available
▲	Phytoplankton counts available; at least 6 samples per year
△	Phytoplankton counts available; less than 6 samples per year
⬟	Zooplankton counts available; at least 6 samples per year
◡	Zooplankton counts available; less than 6 samples per year
▯	Physical parameters of sampling sites available as well as chlorophyll a concentrations

Note: Complete analyses of water samples are published in Water Resources Bulletins 1-1 to 1-5, General Series. Locations are cross-referenced to the relevant Bulletins in Appendix A. Since the sample numbers shown on this map do not appear in any of the Bulletins, cross-referencing must be made through longitudes and latitudes.

Map compilation by Arthur C. Roy
Cartography by B. Fischer